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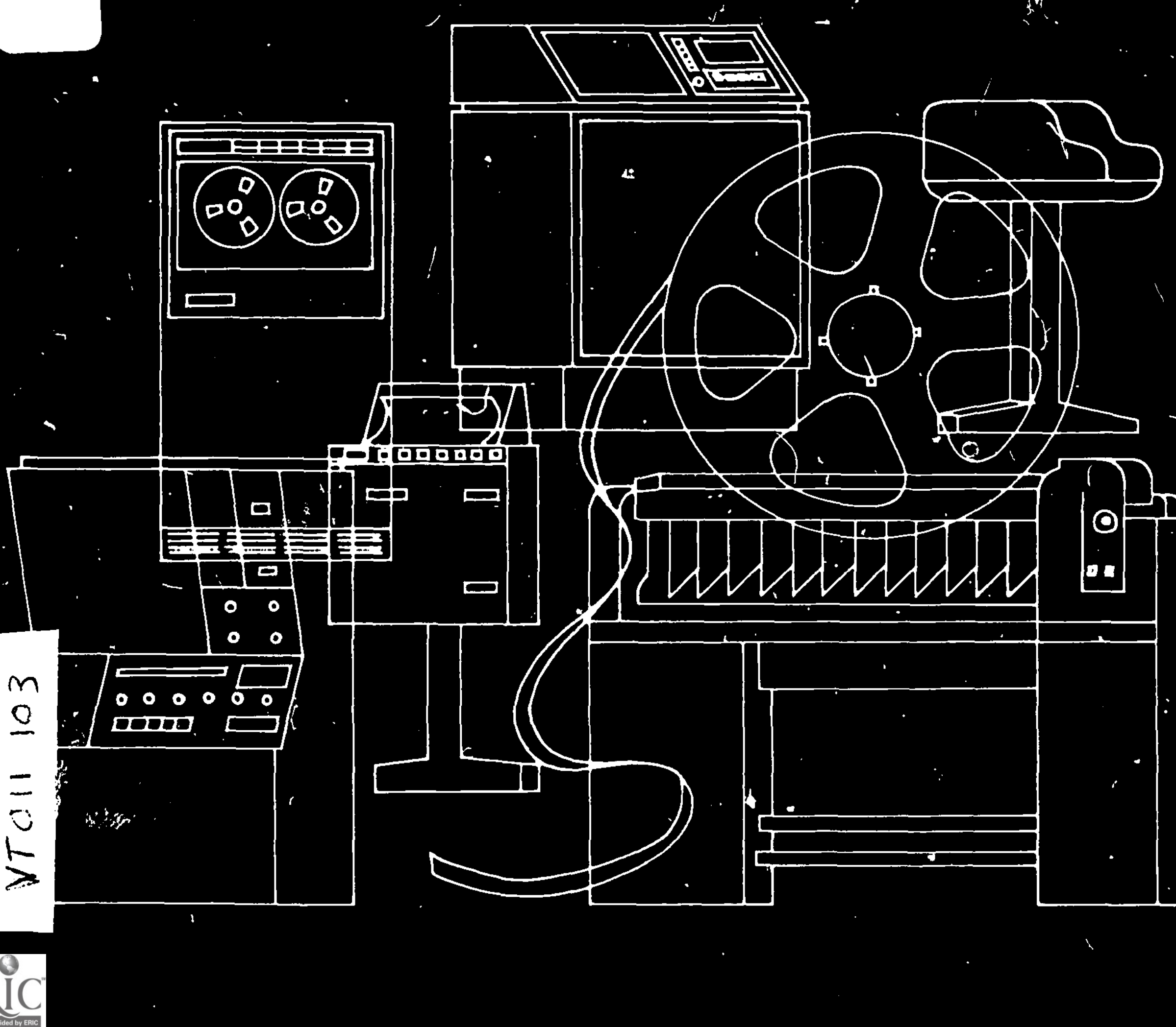
ABSTRACT

Developed by a technical education specialist, this curriculum guide is designed to assist school administrators, supervisors, and teachers in planning and developing new programs or evaluating existing ones in scientific data processing technology, primarily on the post-high school level. Contents include: (1) a suggested curriculum plan, (2) course outlines with examples of texts and references, (3) suggested sequence of technical education procedures, (4) laboratory layouts with equipment and costs, (5) a discussion of remote computation and time sharing, library and its use, faculty, and student services, and (6) a listing of selected scientific, trade, and technical societies concerned with the technology. The 2-year program may be modified to meet local, state, and regional needs. (AW)

Scientific Data Processing Technology

A Suggested 2-Year Post High School Curriculum



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SCIENTIFIC DATA PROCESSING TECHNOLOGY

A Suggested 2-Year Post High School Curriculum

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
ELLIOT L. RICHARDSON, *Secretary*
OFFICE OF EDUCATION
TERREL H. BELL, *Acting Commissioner of Education*

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FOREWORD

Computers used in scientific research make it possible to organize and analyze diverse but related scientific data heretofore beyond the physical capability of the human intellect. Scientific data processing scientists and technicians now routinely solve problems in a few hours that were impossible to solve a decade ago. Computers in scientific research have led to practical space exploration and worldwide television communications, new discoveries about life and matter, comparisons of costs, and construction time for structures such as bridges using different designs and materials, automated chemical processing systems, and many other developments.

These developments have created an increasing shortage of highly qualified scientific data processing technicians to assist physicists, engineers, mathematicians, biologists, social scientists, and medical researchers in solving problems with computers. This suggested curriculum was prepared to aid in planning and developing programs in the United States to meet the Nation's growing need for these specialized technicians.

This guide provides a suggested curriculum plan; course outlines with examples of texts and references; a suggested sequence of technical education procedure; laboratory layouts with equipment and costs; a discussion of remote computation and time sharing, library and its use, faculty, and student services; and selected scientific, trade, and technical societies concerned with the technology. It is designed to assist school administrators, supervisors, and teachers who will be planning and developing new programs or evaluating existing programs in scientific data processing technology. Although the indicated level of instruction is post high school, the sequence of course work may well start at any grade level where students have the prerequisite background and understanding.

This guide was developed by Walter J. Brooking, Technical Education Specialist in the Program Development Branch of the Division of Vocational and Technical Education, Bureau of Adult, Vocational, and Technical Education, U.S. Office of Education. The basic materials were prepared by the Department of Industrial and Technical Education, North Carolina State University, at Raleigh, pursuant to a contract with the Office of Education.

Many useful suggestions were received from special consultants, advisers, and employers using scientific data processing, and from administrators and teachers in schools of technology. Although all suggestions could not be incorporated, each was considered carefully in light of the publication's intended use. In view of this, it should not be inferred that the curriculum is completely endorsed by any one institution, agency, or person. It is a plan for a program; a plan to be modified by administrators and their advisers to meet local, State, and regional needs.

LEON P. MINEAR
Division of Vocational and Technical Education

ARTHUR LEE HARDWICK
Associate Commissioner for Adult, Vocational, and Technical Education

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Mechanical College
Miami, Okla.

Southern Illinois University
Carbondale, Ill.

Technical Institute of Alamance
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CONTENTS

THE PROGRAM

Simulation, queuing techniques, linear programming, gaming theory, critical path methods, mathematical models, and many additional activities can trace their origin to the development of the computer or have received added dimensions as a result of computer capabilities.

The first commercial applications for computers were directed toward achievement of well-established traditional mass data handling objectives at an ever-increasing rate of speed, thus capitalizing upon the speed of computation made possible by the automatic digital computer. The results of this phase of computer usage are well known. New occupations with new educational requirements were described in terms of coders, programmers, systems analysts, and numerical analysts; managers achieved a higher degree of knowledge and control over resources and market potentials; utility companies recognized benefits in the form of punched-card billing practices; hardly an area of business activity was not influenced by this tremendous tool for rapid, complex, and reliable calculation.

With such success in the business arena, it was no wonder that investigations were initiated into possible applications of computers in the scientific areas of human activity. The results were fruitful. Statistical procedures which were strictly theoretical prior to computer applications were exploited and refined; linear programming techniques were developed which offered logical solutions to problems previously "solved" by value judgments and subjective methods; simulation of entire industrial management systems was achieved; automated production lines were fashioned; the critical path methods were devised and resulted in the reduction of production time; mathematical models were developed which expressed the operation of missile flights in a simulated environment; and hundreds of additional activities previously considered impractical were made possible as a result of the power and ability of the automatic digital computer.

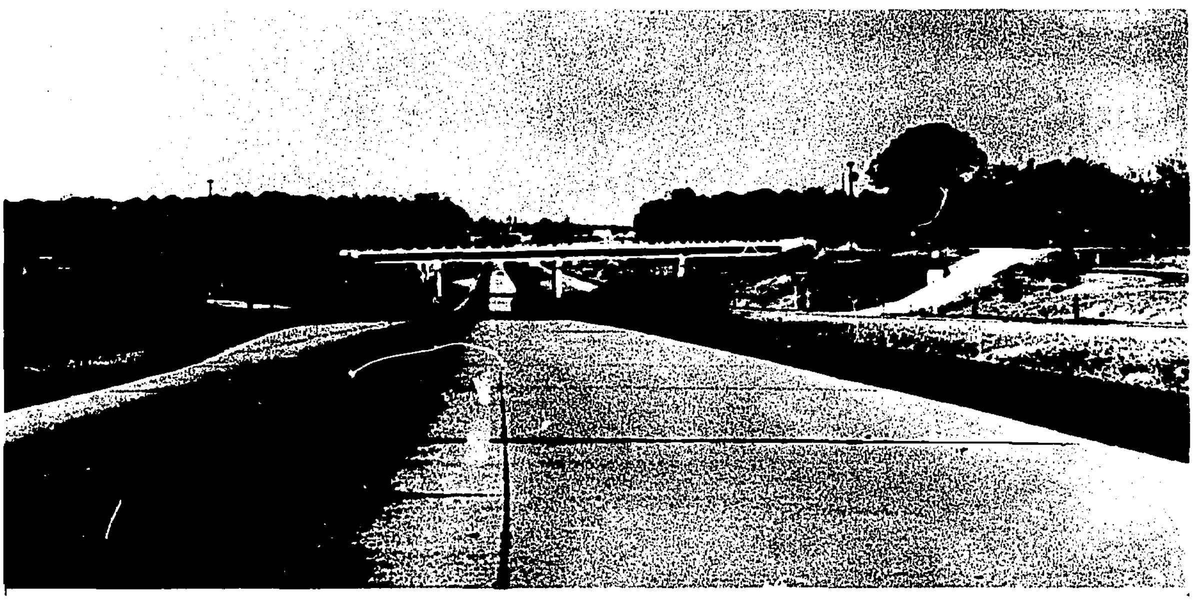


Figure 1.—Highway and safety engineers are avoiding costly delays, improving designs, reducing costs, and increasing highway safety by using scientific data processing programming techniques in model building, simulation, route selection, and application of critical path methods of construction control.

Yet none of these activities is possible without the ever-present human factor in the form of programmers and analysts. It has been said that the major restrictions which the computer

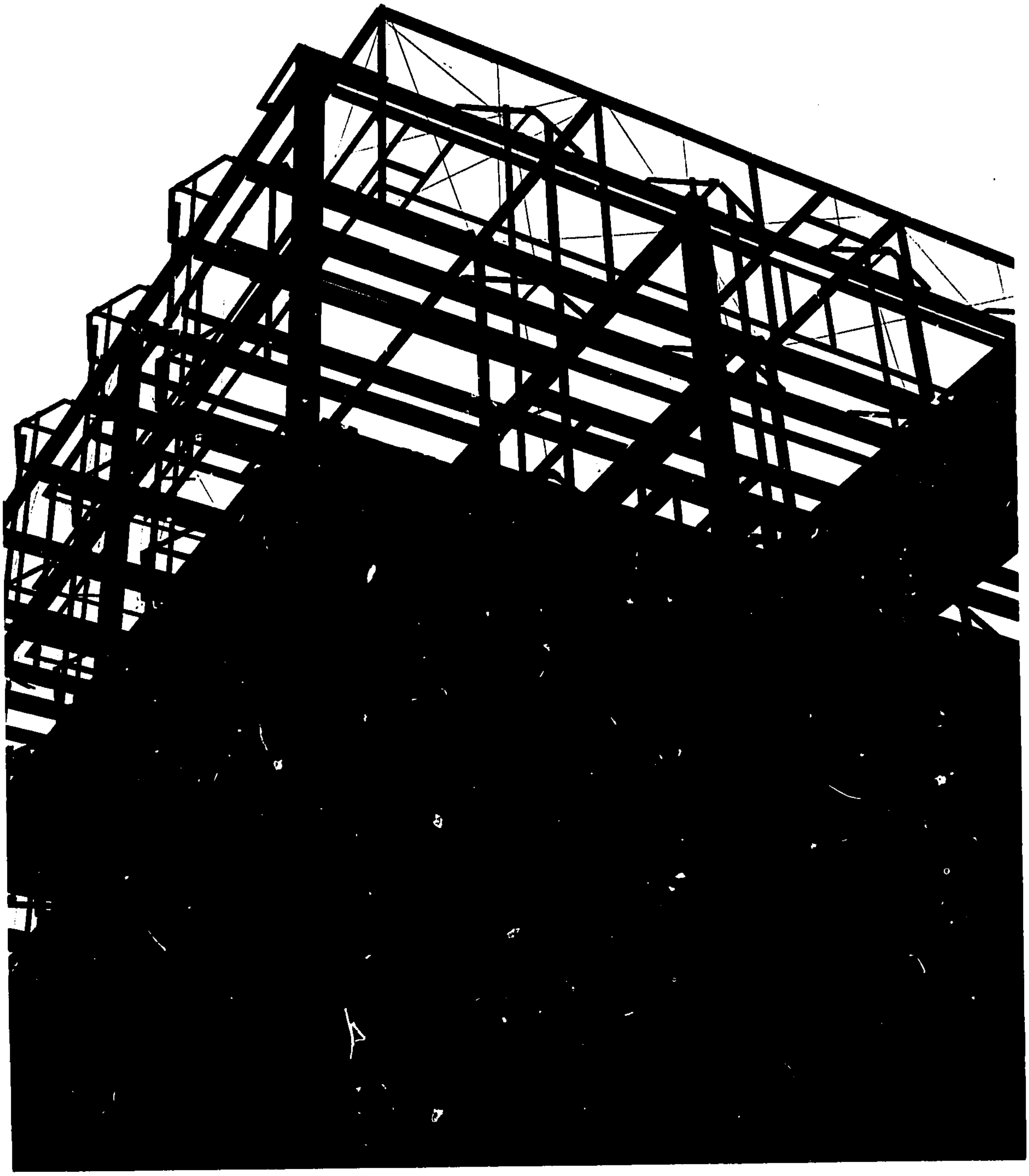


Figure 2.—With the assistance of computers and scientific data processing technicians, engineers who design modern structures such as buildings, bridges, ships, or aircraft can compare the strength and cost of alternate designs using different materials and structural forms by using the information storing and combining capability of computers.

Figure 3.—Complex problems encountered in designing structures or machinery, analyzing complex weather patterns and systems, and many other problems which were impossible to cope with in the past are now solved routinely in minutes or a few hours by scientific data processing technicians who assist engineers.

possesses are the imagination of the human mind and the limitations enforced by the lack of sufficient numbers of the trained personnel needed to guide this remarkable tool toward the limits of its potential. As in other fields of occupational endeavor, it is possible to determine and identify sufficient unique educational elements required to prepare a scientific data processing technician. It is the purpose of this curriculum guide to offer an educational training pattern sufficient to allow a graduate to enter employment in the field of scientific data processing immediately upon graduation and to afford him the necessary skills and knowledge complementary to occupational progression.

The penetration of electronic data processing into more and diversified industrial, business, and scientific applications has created the demand for a new type of technician and, concurrently, new demands on education. Consideration of the educational requirements defined by an analysis of the occupational performance of data processing technicians dictates the recognition of two distinct and separate programmer classifications.

The first classification may be identified by the educational experiences required for successful job performance as a business data processing technician. Educational requirements for personnel operating within this classification must correlate strongly with the performance of data processing applications of a repetitive nature, such as payrolls, inventory control, and billing practices, which are characterized by the term *procedure orientation*. These procedures usually originate with management decisions that become standard operating policy. Thus, the occupational performance of a business data processing technician is, to a large extent, controlled by factors external to his immediate working environment. Such factors dictate a set of operational parameters within which self-developed concepts, in the form of computer program designs, may be realized and required to a limited and predefined degree.

The second classification may be defined by the educational requirements for successful job performance as a scientific data processing technician and must exhibit a strong correlation with nonrepetitive applications. These applications are characterized by the term *problem orientation*, having its genesis in one or more of the disciplines commonly referred to as the physical and life sciences.

The Technician

The occupational performance of the scientific data processing technician is, to a large extent, affected by factors within his realm of control. This offers a maximum opportunity to exercise self-developed concepts limited only by the operational parameters which are dictated by problem characteristics rather than standard operation procedures.

The occupational activities of the scientific data processing technician are characterized by diversity. Development of economic models, simulation techniques, queuing theory, statistical programming, and mathematical models are all within his realm of responsibility. He must, therefore, be equipped with the educational ability to express his ideas and develop concepts in terms which are both implicit and explicit and to conceive of direct and indirect relationships existing between considered factors.

Job descriptions and responsibility assignments in the field of data processing are fluid. This is to be expected in an area where personnel designations are identified in terms which were nonexistent a decade ago. Activities are being performed for which no precedent has been set and often new words are coined to express new concepts and practices. Yet, sufficient stability has been achieved to allow tentative designations for specific job clusters. The first of these is "analyst," which is usually preceded by the adjective "systems" or "numerical." The systems analyst has the responsibility of defining the problem area (usually in a business operation) and expressing the definitions in terms intelligible to a senior programmer. A numerical analyst, the scientific counterpart to the systems analyst, has essentially the same responsibility as the systems analyst, the difference being the source of the problems. With the numerical analyst, the source has a scientific foundation located in the disciplines of mathematics, or physical, or life sciences; whereas the source for the systems analyst has a business foundation located in the disciplines of accounting, business administration, economics, and so forth.

Generally, industry recognizes three levels of programmers. Designations for each level of programmer vary from company to company. The most commonly encountered designations are: (1) senior programmer, (2) programmer, and (3) junior programmer. Normally, a graduate from a technical program offering a course of study as suggested by this curriculum guide

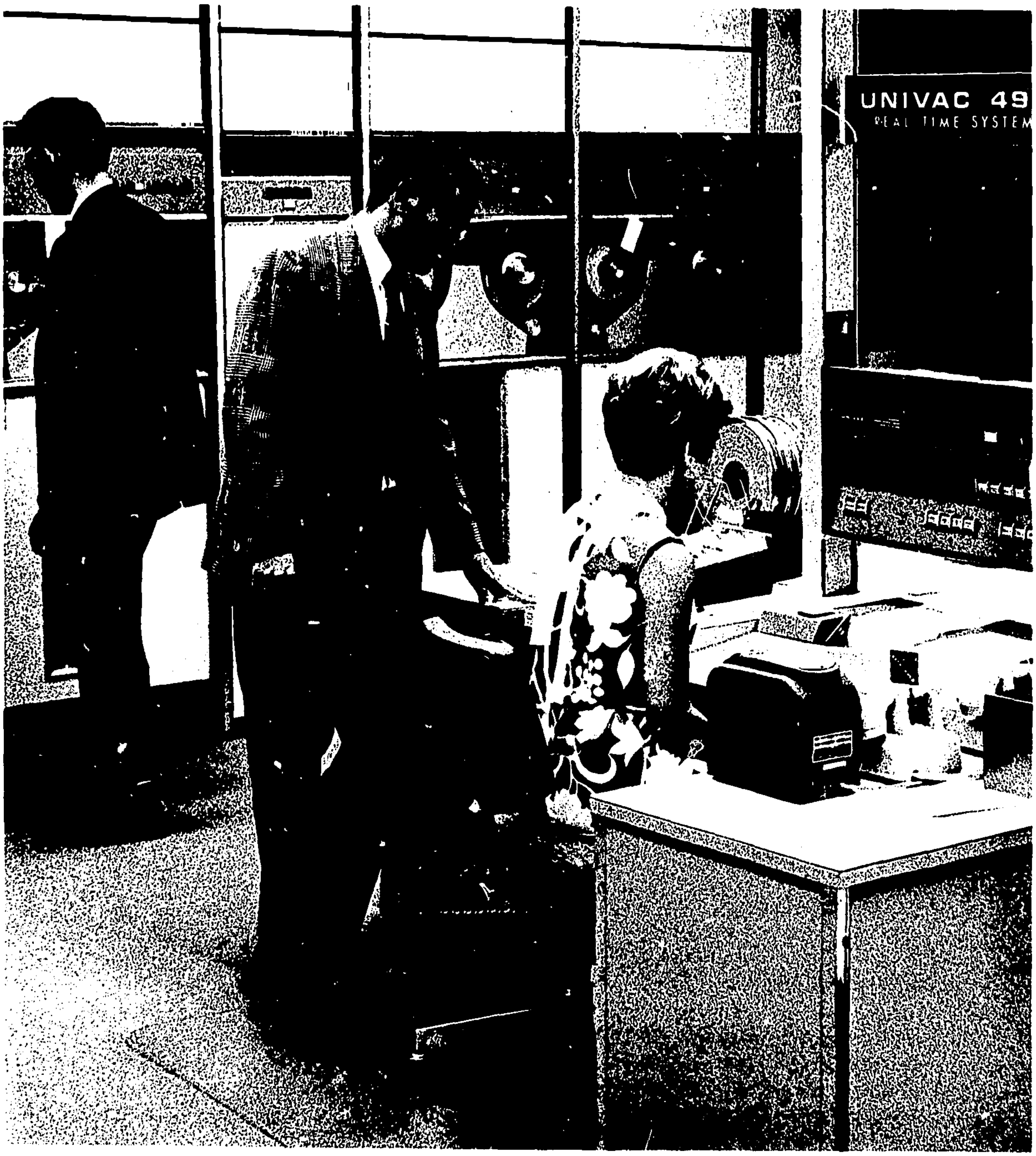


Figure 4.—Real-time computer systems have already proven their value to large airlines by providing instant control of passenger reservations. Similar possibilities for their application in fields such as banking, credit purchasing, utility system loads, and many others promise a tremendous expansion in similar applications. Careers in scientific data processing offer equally great opportunities for women as for men.

could expect occupational entry levels at the programmer and junior programmer levels with, of course, exceptions in unusual cases.

Graduates of this program can expect to find employment in many areas of the scientific data processing field. Each area may require somewhat different abilities and different specialized knowledge and skills for a successful career. Most of these differences will be learned by continued study on the job or in part-time study to master the specifics of a special field. The following listing shows some of the major areas or clusters of job opportunities for scientific data processing technicians as described by employers:

Figure 5.—The data communication terminal which brings to remote locations the capability of a computer system a few miles or half a continent away greatly expands the potential uses of scientific data processing.

(1) Data System Programmer: The programmer evaluates, designs, and implements computer-based systems for real-time acquisition and processing of telemetry and instrumentation data.

(2) Scientific Programmer: The programmer analyzes, programs, and debugs computer solutions of problems arising in missile and space vehicle engineering, such as: guidance and mission planning, space kinetics, spacecraft dynamics, thermodynamics and fluid dynamics, and re-entry and propulsion physics.

(3) Advanced Applications Programmer: The programmer solves problems in the design of computers, electronic components, and physical subsystems, using the digital computer for simulation. Many of the problems involve the use of modern on-line graphics.

(4) Data Processing and Analysis Programmer: The programmer works with problems that include all phases of scientific, engineering, and medical data processing and analysis. Current areas of emphasis are: range tracking, antisubmarine warfare, medical information retrieval, and statistical analysis.

A programmer must possess the ability to accept problem definitions, as presented by the numerical analysts, refine such definitions with the aid of library facilities, conferences, design flow charts, and logic diagrams which completely express the problem and define objectives, code the flow chart in one of the many accepted computer languages, compile the program, debug where necessary, execute the completed computer program, and provide the answers obtained to the problem source.

Technical education programs are devoted to teaching highly specialized personnel who must be capable of performing many tasks requiring special skills and who must be nearly professional in education, attitude, and competence. They provide a carefully structured, rigorous study of scientific principles and supporting mathematics plus an intensive laboratory-oriented program of instruction. This type of program is required to provide (1) the knowledge of applied scientific principles and of the hardware, processes, procedures, techniques, materials, and modern measuring and control devices and (2) the ability to communicate with the professional engineer or scientist doing research, development, or production. Such programs are generally designed for 2 years of intensive post high school study, but many technical and some comprehensive high schools provide technical and related vocational education.

Some indication of the special nature of programs to educate highly skilled technicians,

Figure 6.—Students of scientific data processing must master the operation of the unit record card punch machines and other elements of the data recording and storage equipment as well as programming and operation of the computer itself. They must understand all of these elements even when using remote computer facilities by means of a terminal far removed from the central system.

whether in the engineering-related field, data processing, specialized occupations, agricultural production, or research and development may be obtained from an analysis of what technicians must know, what special abilities they must possess, and what they must be able to do in their daily work.

Special Abilities Required of Technicians[1]

Technicians must have the following special abilities:

1. Proficiency in the use of the disciplined and objective scientific method in practical application of the basic principles, concepts, and laws of physics and chemistry and/or the biological sciences, as they comprise the scientific base for the individual's field of technology

2. Facility with mathematics: ability to use algebra and trigonometry as tools in the development and definition of, or to quantify, scientific phenomena or principles; and, when needed, an understanding of, though not necessarily facility in, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology

3. A thorough understanding and facility in the use of the materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used in the technology

4. An extensive knowledge of a field of specialization with an understanding of the application of the underlying physical or biological sciences as they relate to the engineering, health, agricultural, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish effective rapport with the scientists, doctors, managers, researchers, or engineers with whom he works and to enable him to perform a variety of detailed scientific or technical work as outlined by general procedures or instructions, but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data

5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas with complete objectivity orally, graphically, and in writing.

Activities Performed by Technicians[2]

A list of activities, some combinations of which any technician must be prepared to perform, follows:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to physical and/or biological scientists, engineers, or medical personnel engaged in scientific research and experimentation

2. Designs, develops, or plans modifications of new products, procedures, techniques, processes, or applications under the supervision of scientific, engineering, or medical

[1] Adapted from *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs* (OE–80015). Washington, D.C.: U.S. Government Printing Office, Superintendent of Documents. 1962.

[2] *Ibid.*

personnel in applied research, design, and development

3. Plans, supervises, or assists in the installation and inspection of complex scientific apparatus, equipment, and control systems

4. Advises regarding the operation, maintenance, and repair of complex apparatus and equipment with extensive control systems

5. Plans production or operations as a member of the management unit responsible for efficient use of manpower, materials, money, and equipment or apparatus in mass production or routine technical service

6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical apparatus, equipment, services, and/or products

7. Assumes responsibility for performance of tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences; and/or for determinations, tests and/or analyses of substances in the physical, agricultural, biological, medical, or health-related sciences; and prepares appropriate technical reports covering the tests

8. Prepares or interprets engineering drawings and sketches, or writes detailed scientific specifications or procedures for work related to physical and/or biological sciences

9. Selects, compiles, and uses technical information from references such as engineering standards; handbooks; biological, agricultural, or medical and health-related procedural outlines; and technical digests of research findings

10. Analyzes and interprets information obtained from precision measuring and recording instruments and/or special procedures and techniques and makes evaluations upon which technical decisions are based

11. Analyzes and diagnoses technical problems that involve independent decisions. Judgment requires, in addition to technical know-how, substantive experience in the occupational field

12. Deals with a variety of technical problems involving many factors and variables which require an understanding of several technical fields. This versatility is a characteristic that relates to breadth of applied scientific and technical understanding—the antithesis of narrow specialization

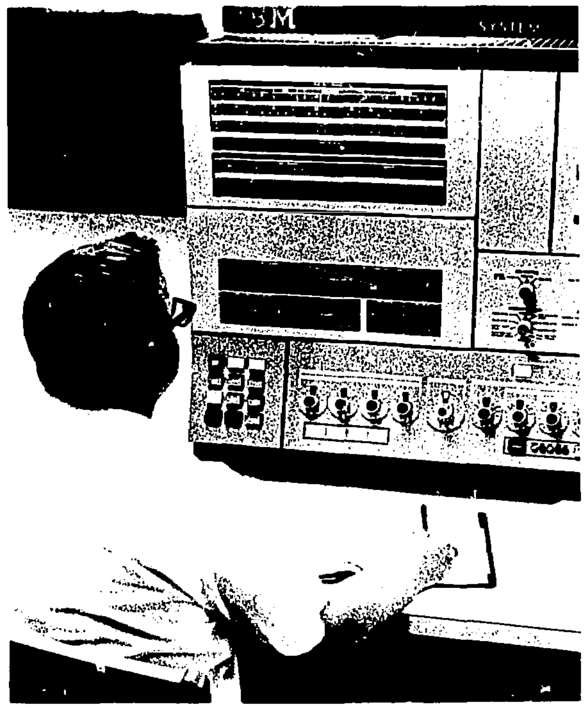


Figure 7.—Hands-on experience in operating the computer is an essential and vital part of the scientific data processing student's learning process.

It is, of course, recognized that no 2-year technical program can hope to equip a student with all the knowledge required to meet the demands of every problem he may conceivably encounter. However, a well-organized and well-administered 2-year post high school curriculum for scientific data processing technicians will offer to industry and research organizations the skill and knowledge required to forward computer application toward the limit of its potential and afford the programmer an opportunity to participate in an exciting and fascinating area of occupational endeavor.

A 2-year program must concentrate on primary or fundamental needs if it is to prepare individuals for responsible technical positions in modern industry. It must be realistic and pragmatic in its approach. *The program sug-*

gested in this bulletin has been designed to provide maximum technical instruction in the time that is scheduled.

To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it), the technical program often appears to be inordinately rigid and restrictive. While modifications may be necessary in certain individual institutions, the basic structure and content of this program should be maintained.

The specialized technical courses in programming are laboratory oriented. They provide application of the scientific principles concurrently being learned in the courses in statistics and mathematics. *For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program.* This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms, a program principle that will be illustrated at several points. General education courses constitute a relatively small part of the total curriculum. It has been found that students who enter a technical program do so because of the depth in the field of specialization that the program provides. Experience shows that many students who elect this type of program will bring to it a background of general study.

Faculty

The competence and enthusiasm of the teaching staff will determine in large measure the success of this curriculum. The specialized nature of any technical curriculum requires that the instructors of technical subjects possess technical knowledge based on educational experience and an up-to-date awareness of industrial procedures relative to his particular specialty. It is also important that each member of the faculty understand the educational philosophy, goals, and unique requirements that characterize this area of education.

A well-qualified instructional staff is essential to the success of this curriculum. The qualifications needed in this program include technical competence, industrial experience, and professional acumen. Professional training in educational processes and teaching methods should be required of all teachers. Any compromise with teacher qualifications must realize the possibility of limiting the stated objective of this curriculum which is: to prepare a student who is immediately employable as a scientific computer programmer and one who has sufficient academic experience to support his desires of advancement in the work of his choice.

Ideally, all instructors involved in teaching this curriculum would understand the knowledge and skills required of each student in each course and have a particularly keen conviction of the contribution of his specialty toward achieving the total curriculum objective. Realistically, however, it is hoped that each instructor teaching courses within this curriculum will have a general knowledge of contributions offered by each course and a detailed, specific knowledge of the contributions offered by his course. To optimize the objective function of this curriculum, it must be recognized that each individual course of study offers a positive contribution toward achievement of the final goal. It is strongly suggested that a lead instructor, or department head, be designated to assure that maximum continuity exists between *all* courses and that all instructors are conscious of the need for well-integrated courses if the scope and depth of training given the student are to be adequate in the 2-year time allowance.

Teachers of specialized technical subjects require advanced technical training and industrial experience. Many institutions have recruited instructors from the ranks of industrial manpower. Many excellent instructors have started their full-time teaching career as part-time evening instructors who maintained full industrial employment during the day. This arrangement offers many benefits to the institution as well as the instructor and students. Benefits to the student are recognized in considering the timeliness of relating current industrial practices to the learning process.

Faculty members should strongly consider the value obtained from periodic departmental meetings. Such meetings, if properly conducted, offer an opportunity to foster and encourage the recognition of a unified opinion relative to curriculum goals, evaluate courses of study, offer suggestions of course changes necessary to maintain a high degree of correlation between industrial practices and course content, and discuss solutions to common problems which are related to the execution of an effective curriculum. All faculty members should be encouraged to participate in the activities of professional and technical societies. To be effective, they must keep up with the literature in their field, and maintain close liaison with industry in the area of their specialties. This encouragement may be provided in the form of released time and financial assistance to attend special institutes. Periodic sabbatical leave for industrial experience or further study should be encouraged. To provide periodic service as industrial consultants in their specialized fields has also been found to be an incentive to further study and professional development for faculty members. It also affords industry an opportunity to recognize the professional competencies of institutional faculty.

When teaching loads for faculty members conducting specialized technical courses are determined, consideration should be given to the number of *contact* hours rather than to the normal assignments for vocational shop instructors. It must be considered that instructors of the specialized courses devote a large amount of time in preparation for laboratory sessions, for the development of special instructional aids, for assisting students with individual projects, and for reviewing reports—in addition to their usual teaching responsibilities. An acceptable teaching load probably would be 15 to 20 contact hours per week. Total effectiveness of the teaching staff may be increased by use of a trained, nonteaching laboratory assistant to assist individual students in program debugging and in the creation of source programs for computer entry.

Class size should be limited to approximately 25 students, especially where laboratory programs are involved. It is suggested that each laboratory assignment be carefully evaluated relative to computer processing time and that a procedure for sign-on and sign-off be established which will assure that each student has sufficient computer time allotted to him and that no one program be allowed to monopolize computer capability for debugging purposes.

Student Selection and Services

It is essential that students accepted into the program have certain capabilities. If the incoming students' backgrounds are inadequate, instructors will tend to compromise the course work to allow for the inadequacies with the probable result that the program will be inadequate in depth and scope.

Students selected for this program should have similar background experiences and capabilities and should exhibit evidence of maturity and seriousness of purpose; otherwise, the program will only achieve its objective to a limited degree. Wide ranges of student ability will adversely affect the teaching situation, thereby preventing progression of the program at the necessary level and rate. The nature of the material presented and the concepts to be mastered dictate the acceptance of students who are not only well prepared in formal course material, but who have the ambition, desire, and will to master a difficult program and develop their capabilities to the limit.

The curriculum is designed for high school graduates who have particular abilities and interests. Students entering the program should have completed 2 years of high school mathematics, including simultaneous linear equations, exponentials, and radicals; and 1 year of laboratory science, preferably chemistry or physics. It is expected that the ability of prospective students to meet these requirements will vary greatly; some students will require refresher courses in mathematics, science, or English to make satisfactory progress in the program. Any deficiencies in mathematics or science should be remedied prior to student admission into the formal classes. Many institutions provide pretechnical post high school programs to assist promising but underprepared students to overcome scholastic handicaps and become technicians.[3]

Effective guidance and counseling are essential. Consistent with individual interests and aptitudes, aid should be available in selecting educational and occupational objectives. Whenever possible, institutions offering technical education programs should consider the use of standardized or special tests to assist in student selection, placement, and guidance. A student should be advised to revise his educational objectives if it becomes apparent that he is more suited to other programs.

[3] U.S. Department of Health, Education, and Welfare, Office of Education. *Pretechnical Post High School Program, A Suggested Guide* (OE-80049). Washington, D.C.: U.S. Government Printing Office, Superintendent of Documents. 1967.

The graduate should be given all possible assistance in finding suitable employment. Placement personnel should be cognizant of industrial needs and should acquaint prospective employers with the qualifications of graduates. The placement function is extremely valuable to the student, the institution, and industry. In the final analysis, the placement function becomes a planned cooperative effort between the personnel service organization, instructors, and department heads. It is the responsibility of the school to form a followup procedure of graduate activity. This will result in an effective evaluation measure because the graduate can provide valuable advisory services by reporting back to the school the strengths and weaknesses of the program.

Textbooks and References

Textbooks and references for teaching any technology must be reviewed constantly and supplemented in light of (1) the rapid developments of new knowledge in the field and (2) the results of research in *methods* of teaching and developing basic concepts in the physical sciences and mathematics. This is especially true in the field of data processing. The development of whole new areas of theoretical and applied scientific knowledge demands new textbooks, new references, articles in scientific and technical journals, and new visual aids material.

New textbooks will reflect recent methods of teaching scientific principles and applications as fast as current research in education becomes applicable. Recent extensive research in methods of teaching mathematics and physics certainly will produce changes in teaching materials and methods. It is therefore mandatory that instructors constantly review modern texts, references, and visual aid materials as they become available and *adopt* them when they are an improvement over those suggested here or those presently in use.

The suggested texts and references have been carefully selected. From the lists presented, it should be possible to select suitable ones. However, it should not be interpreted as suggesting that unlisted books are not suitable—there are, no doubt, others which are excellent.

It is urged that before a department head or instructor undertakes a program in scientific data processing technology, or any course contained in the curriculum, he familiarize himself with the texts and references listed here and others which are available. He will then be able to select the text which best serves his particular needs in making a lucid, high-level technical presentation to his students.

Laboratory Equipment and Facilities

Laboratory experience is a vital part of this program and is considered absolutely essential to the achievement of the curriculum objective. Beyond the initial exploratory phases, all experiments contain a degree of commonality recognized in the procedure characteristics. Each laboratory assignment begins with a clear and distinct statement of the problem, followed by the development of a well-designed flow chart. After each flow chart has been desk-checked with test data, a program is written in a language specified by the course of instruction and the system configuration. This source program is transferred to a medium acceptable to the computer system. It is to be noted that all steps of program preparation which have been revealed up to now require no computer time, but do absorb laboratory time in the utilization of program preparation equipment. After the source program has been transferred to a suitable medium for computer acceptance, an object program is prepared by the computer and data accepted for problem solution. It should be noted that the relationship between the time the project has proceeded to the point of computer acceptance and computer solution is largely identified as time consumed independent of computer availability. The reason for this detailed discussion of laboratory procedure is to allow proper interpretation of laboratory time designated in the course outlines and assure that the designation of time allocations is not interpreted to be considered computer time exclusive of auxiliary equipment.

Equipment selection is a consideration of prime importance to the effectiveness of the curriculum. Selection should be based on how well the instructional environment simulates industrial practices. Although the curriculum is oriented toward machine independence, it is important to recognize the necessity for selecting equipment capable of accepting languages which enjoy a wide range of industrial use.

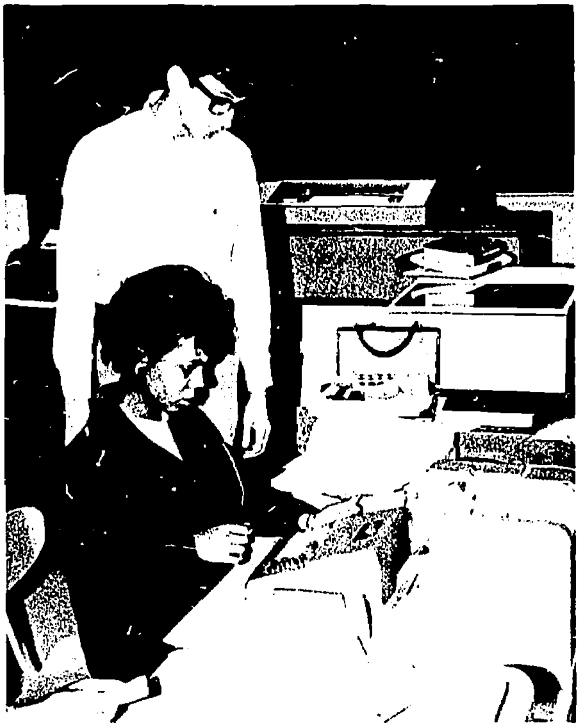


Figure 8.—Up-to-date peripheral data processing equipment such as this unit record card punch machine or equivalent representative of current and emerging data processing equipment and practice must be available in sufficient quantity to permit all beginning students to become familiar with it and have real experience in its use.

The equipment used in a scientific data processing laboratory is expensive and tends toward obsolescence after a few years of use. Many equipment manufacturers offer a lease program with an educational discount. The question of lease or purchase is one which each institution will have to resolve. There are advantages and disadvantages to each. It will suffice here to point out that a danger exists in attempting to utilize a purchased system beyond the limits of practicality, whereas a leased system is more easily "modernized" when economic concern is paramount.

Consideration should be given to the choice of utilizing remote terminal units connected to a conveniently available large central computer facility whenever such a facility offering such a service is located in the area. This may well prove more economical than investing in a central processing unit to be installed in the institution itself. Furthermore, access to a machine much larger and more powerful, and therefore possessing far greater capabilities than one likely to be found suitable for an educational institution, would provide opportunities for more comprehensive programming exercises.

Figure 9.—Scientific data processing technicians cannot obtain the understanding, experience, and confidence they require without having the real computer such as this one as a part of the equipment they can operate. Remote communication data processing terminals alone are insufficient to provide students with real understanding of computer operation.

Obviously, there are many system configurations which will meet the minimum requirements for a technical program as described by the following course outlines. However, much wisdom is recognized in utilizing professional advice and recommendations which can be expressed by active advisory committees consisting of programmers, employers of programmers, and educators. No decisions on procurement of equipment should be taken without this valuable advice.

A further consideration which should be kept in view when planning the facilities for a scientific data processing laboratory is the probability that the nature of the equipment may require some remodeling of the area in which it is to be installed. For example, raised flooring may be necessary to accommodate electrical cables. Furthermore, air conditioning may be highly desirable, both to promote human comfort and to provide the humidity and temperature control which are essential to the efficient performance of the equipment and materials.

Each student should have allocated to him specific computer times which will allow independent operation. It will be necessary to establish procedures which minimize individual monopoly and yet encourage activities beyond those specified as course requirements. This may be accomplished by exerting tight control on "prime" time with sufficient time available after school and evenings for student use beyond the limits established by the course.

Scientific and Technical Societies[4]

Scientific and technical societies are an important source for instructional materials and other potential opportunities for benefits to both staff and students. Such societies provide, in their publications and in their regularly programmed meetings, a continuing disclosure and discussion of new concepts, processes, techniques, and equipment in the science and related technologies. They are probably the greatest single device by which persons interested in applying a particular phase of science keep abreast of new developments. Their data are presented in such manner as to provide a "popularizing" and informative bridge between the creative theoretical scientist and the applied sciences practitioners, including the technicians, and usually are the first medium to announce and describe significant discoveries and applications of research in the field.

Teachers in technical programs should be encouraged to become acquainted with the people in the community who are most actively interested in their fields. Some educational institutions pay all or part of the cost of membership in selected societies and all or part of the cost of attendance at local or national society meetings as a means of encouraging staff activity in such societies.

Early in their study program, students should be made aware of the literature and services of scientific, technical, and engineering societies relating to computers and automation. Student affiliate memberships are offered by some of these societies, and students should be encouraged to take advantage of such opportunities. A brief description of some of the societies related to data processing is given in appendix A.

Advisory Committees and Services

Experience has shown that almost all successful technical education programs are assisted and benefit by the use of advisory committees and special consultants. Most institutions have an advisory committee or committees to assist the administration in planning and implementing overall programs to meet the objectives of the institution and the needs of those whom it serves. In addition, each specific technology program or other specialized occupational objective has a special curriculum advisory committee made up of representatives of employers, civic leaders, public employment services, scientific or technical societies and associations in the field, and the specialists from the staff of the school.

The curriculum advisory committee usually is appointed by the chief administrator or the dean of the institution when it becomes evident that a particular technology should be considered as a program to be offered by the institution. The advisory committee then assists in making the necessary survey of the needs for the technicians—what they should be able to bring to an employer to meet the requirements of the employment opportunities; available student population, curriculum, faculty, laboratory facilities and equipment; and cost and financing of the program. Often the committees provide substantial support to school administrators in requesting appropriations, raising public funds, and obtaining State or Federal support for the program.

Sometimes the studies of the curriculum advisory committee show that a proposed program should not be undertaken. When the studies indicate that a program should be initiated, the support and assistance of the committee in planning and initiating the program is invaluable. When the first few classes of students graduate and seek employment, the committee assists in placing them in jobs and helps to evaluate their performance. Minor modifications often are made in the program as a result of these evaluations.

Committee members usually are appointed for a year so that the duties will not become a burden to any individual member and so that other qualified and interested people may have the opportunity to serve. The average committee usually consists of about 12 members, but this number may vary from 6 to 20. Those selected to serve are usually busy people and meetings should be called only when there are prob-

[4] U.S. Department of Health, Education, and Welfare, Office of Education. *Scientific and Technical Societies Pertinent to the Education of Technicians* (OE-80037). Washington, D.C.: U.S. Government Printing Office, Superintendent of Documents. 1966.

lems to be solved or tasks that committee action can best accomplish. The head of the institution or department head of the technology usually serves as chairman. Such committees serve without pay as interested citizens. They enjoy no legal status, but they provide invaluable assistance whether serving formally or informally. The continuous support of an advisory committee has been found to be a constant source of strength for the program and the most reliable means of maintaining a successful, high quality, and up-to-date program. It is expected that adaptations in this program will need to be made to suit various situations in schools in differing localities. The assistance of an advisory committee and of special consultants, using a curriculum guide such as this as a starting point and modifying it to meet local needs, has been found to be an effective means of initiating needed programs and developing them quickly to a high level of excellence. The courses in guides such as this have often been modified by schools and their advisers to serve the needs of employed adults who need to update or upgrade their skills and technical capability.

The program is not intended to make the individual proficient in all of the duties he might be asked to perform. Proficiency in work of a highly specialized nature will come only with practice and experience. It is impossible to forecast the exact requirements of the duties assigned to any individual, and it is almost impossible to predict accurately the course or rate of change of various technologies. Employers generally recognize that recent engineering graduates may require a year or more to obtain the specific training needed and to orient themselves to their responsibilities and roles in an organization. Similarly, employers of newly graduated data processing technicians must generally expect to provide a 3- to 6-month period of orientation to the special situations, processes, and problems encountered on the job. Furthermore, the productive graduate technician will continue to study throughout his career in order to develop to his fullest capabilities.

THE CURRICULUM

Curriculum Outline

	HOURS PER WEEK			
	Class	*Laboratory*	*Outside Study*	*Total*
FIRST SEMESTER				
Scientific Data Processing Technology Seminar	1	0	2	3
Introduction to Data Processing	3	6	6	15
Communications Skills	3	0	6	9
Technical Mathematics I	5	0	10	15
Techniques of Real-time and Remote Computation	3	2	6	11
	15	8	30	53
SECOND SEMESTER				
Statistics	5	0	10	15
Technical Mathematics II	4	3	8	15
Statistical Programming and the Life Sciences	3	6	6	15
Graphical Representation	0	4	0	4
Technical Reporting	2	0	4	6
	14	13	28	55
THIRD SEMESTER				
Fundamentals of Scientific Computation	3	6	6	15
Boolean Algebra	4	0	8	12
Linear Programming	3	6	6	15
Industrial Organizations and Institutions	3	0	6	9
	13	12	26	51
FOURTH SEMESTER				
Programming for Engineering Applications	3	6	6	15
Introduction to Operations Research	3	6	6	15
Field Project	2	6	4	12
General and Industrial Economics	3	0	6	9
	11	18	22	51

Brief Description of Courses

FIRST SEMESTER

Scientific Data Processing Technology Seminar

A seminar course designed to present to the student an opportunity to gain an overview of the curriculum and occupational requirements for scientific data processing technicians. Exposure to industry and industrial requirements is obtained by having industrial representatives meet with the students and instructor in panel discussions. This course is of considerable value in offering to the student the information required in order to program his objectives in regard to his academic activities as well as later job performance.

Introduction to Data Processing

A course designed to introduce the student to the fundamental concepts of electronic data processing. It assumes a student with no previous knowledge of data processing procedures and techniques and offers the opportunity for organized orientation prior to specific computer courses. It is a prerequisite for all other computer courses within the curriculum.

Communications Skills

A course dedicated to the proposition that greater competence in reading, writing, talking, and listening results in a technician with decided advantages relative to job performance and promotion.

Technical Mathematics I

A course of study which assumes the satisfactory completion of a minimum of one semester of high school algebra and is the first of two mathematics courses designed specifically for scientific data processing. The sequence of presentation is traditional and adherence to its order is strongly urged.

Techniques of Real-time and Remote Computation

A course to give the student a general understanding of, and appreciation for, the capabilities and limitations of recent developments in computer usage. The course progresses from the stage of hardware considerations through basic concepts of operating systems and data management techniques. Close coordination is necessary between the concepts offered in this course and those offered in *Introduction to Data Processing*.

SECOND SEMESTER

Statistics

A course having as its objective acquainting the student with the theory of statistics and its application to scientific procedures. Special emphasis will be placed on those statistical techniques which lend themselves to the advantages of computer solution.

Technical Mathematics II

A course that presents the fundamental concepts of the calculus and offers an introduction to general methods of solution. Emphasis is directed toward the practicality of calculus solutions to defined problems and the relationship of the calculus to computer solution. Laboratory time is directed to computer solutions of problems designed to support the theoretical concepts presented in class.

Statistical Programming and the Life Sciences

A course, which, in the first section, expands on the FORTRAN concepts presented in the course entitled *Introduction to Data Processing*. The FORTRAN programming language developed in this course will serve as the carrier of concepts and programming abilities for future programming courses within the curriculum. The second section of this course presents mathematical and statistical techniques to illustrate how programming can be used in the field of life sciences.

Graphical Representation

A course which emphasizes methods of presenting, summarizing, and using information effectively. Techniques presented are: drawings, prints, sketches, graphs, charts, and diagrams. The use of graphs, mathematical relationships, drawings, and diagrams to present significant points is an important portion of this course.

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of graphs, drawings, sketches, and outlines for various types of oral and written reports.

THIRD SEMESTER

Fundamentals of Scientific Computation

A course designed to present to the student those topics in numerical analysis and allied mathematical subjects that are most relevant to the use of digital computers in the solution of engineering and scientific problems. Each major topic is presented in terms of computer applications and is supported by extensive laboratory projects.

Boolean Algebra

A course presenting those aspects of logical mathematics and Boolean algebra most closely associated with computer programming and logic. Emphasis is directed toward the use of Boolean algebra as an aid in understanding fundamental concepts of logical design and verifying proper computer performance.

Linear Programming

A presentation of the basic concepts of linear programming techniques and objectives and the identification of the position of linear programming problems within the fields of management, scientific techniques, and operations research.

Industrial Organization and Management

A course designed to help students gain a knowledge of industry and its organization. Various phases of the industrial process and basic relationships between management and labor are included, together with problems encountered in working with others.

FOURTH SEMESTER

Programming for Engineering Applications

A presentation of the concepts of computer applications to the broad field of engineering. Each division within the course represents a distinct and separate area of engineering applications and is designed to afford to the student an understanding of the versatility of the computer and an orientation to the presented areas of application.

Introduction to Operations Research

A course designed to present an overview of the techniques and tools employed in operations research. A successful technician in scientific data processing must know the fundamental principles involved in the application of the most modern concepts in problem solutions. The approach is directed toward the understanding of general aspects, term definition, and the observance of the proper relationships which exist between methods of solution and problem characteristics.

Field Project

A course in which the student selects, develops, and solves a scientific data processing problem. This course is highly personalized as to individual student activity and interest. Assignments are determined on the basis of interest expressed by the student, and the instructor's evaluation of prior academic performance. Emphasis is directed toward the solution of meaningful scientific problems or applications which require command of the total system concept.

General and Industrial Economics

A study of general economic principles and an analysis of the factors involved and the importance of cost control in an industrial or municipal enterprise.

Curriculum Content and Relationships

Functional competence in a broad field such as scientific data processing technology has at least three objectives around which the curriculum must be structured: (1) the training should prepare the graduate to take an entry job in which he will be productive; (2) the broad, technical training, together with a reasonable amount of experience, should enable the graduate to advance to positions of increasing responsibility; and (3) the foundation provided by the training should be broad enough so that the graduate can do further study within his field of technology. This curriculum has been designed to meet these three objectives.

A 2-year technology program has certain unique requirements that influence the content and organization of the curriculum. Some of these requirements are imposed by the occupational functions that graduates must be prepared to perform; some result from the need for special courses that will maximize the effectiveness of teachers who have special competencies; and others arise because of the need to teach both technical principles and related practical applications in the limited time available.

The sequence of the courses in a 2-year technical curriculum is equally as important as the content of the courses. In general, the subject matter in the curriculum is carefully correlated in groups of concurrent courses. This is in sharp contrast to the arrangement of professional curriculums in which basic and somewhat unrelated courses make up the first part of the study program and specialization is deferred to subsequent terms. In technical curriculums, it is mandatory that specialized technical course work be introduced in the first term. Deferring this introduction even for one term imposes serious limitations on the effectiveness of the total curriculum. Several important advantages accrue from the early introduction of the technical specialty: (1) student interest is caught by practical aspects of instruction, whereas, if the first term consists entirely of general subjects—mathematics, English, social studies—students often lose interest; (2) it is possible to obtain greater depth of understanding in specialized subjects in the latter stages of the 2-year program; and (3) there is practice in the application of mathematics in the technical courses. Thus, the student's study in mathematics is reinforced by the application of the discipline in the technical field of his choice.

The course outlines are concise and comprehensive and are intended as guides rather than as specific instructional plans to be covered in an inflexible order. They represent a judgment on the relative importance of each instructional unit, especially where time estimates are shown. It is expected that the principles outlined in these courses will be supplemented with industrial applications whenever relevant. Field trips add greatly to the effectiveness of the instruction if they are carefully planned in advance so the processes observed will be understood and will be related to the subject material being studied at the time of the trip.

Outside study is a significant part of the student's total program. In this curriculum *2 hours of outside study time have been suggested for each hour of scheduled class time.* A typical weekly work schedule for a student in the first semester of this curriculum would be: class attendance, 15 hours; laboratory, 8 hours; and outside study, 30 hours—a total of 53 hours per week. This is a full schedule, but it is not excessive for this type of program.

It should be noted that no examinations have been scheduled in the outlines. It is clearly intended that time be available for examinations. Therefore, a 17-week semester is assumed, and the outlines are designed to cover a full 16 weeks. The primary objectives of examinations would be to evaluate the student's knowledge and to cause him to make a periodic comprehensive review of the material presented in the course. Examination results also may point out weaknesses in teaching techniques or in coverage of subject matter.

The course outlines in this guide are short and descriptive. Each individual instructor will have to prepare complete courses of study for each lecture unit and select laboratory experiments designed to support the theoretical portion of each course.

The first-semester courses are offered as foundations upon which each successive semester is built. *Scientific Data Processing Technology Seminar* is designed to offer to the student a realistic overview of the data processing activities in industry and the requirements of personnel. This course permits the student to realistically plan his program of education in view of his occupational objectives.

Introduction to Data Processing assumes no previous knowledge or experience and presents an opportunity to observe many of the current industrial practices relative to automation. The first half of this course is nonspecific in the sense of tightly related concepts. It is general—designed to offer an overview of the activities of data processing technology. The second half of this course presents an introduction to two current and popular programming languages. One of these, FORTRAN, will be expanded in the next semester and applied in statistical programming. *Technical Mathematics I* provides the mathematical tool required for the last half of *Introduction to Data Processing* and forms a basis from which the tool may be expanded for future courses in the curriculum. *Techniques of Real-time and Remote Computation* presents to the student the concepts of real-time computer utilization as a special technique to handle problems requiring a continuing input of data with immediate output of solutions and gives him an understanding of the organization of a large central computer facility accessible to users at a distance through terminal units. This course is taught concurrently with *Introduction to Data Processing* and must be closely coordinated with it. Concurrently with the gaining of skill and confidence in the technical specialty during the first semester, the student also learns to write technical reports. The knowledge gained from *Communications Skills* will be applied in the documentation of laboratory experiments in all semesters and more particularly in the *Field Project* of the last semester.

The *Statistics* and *Statistical Programming and the Life Science* courses, which are offered in the second semester, will require close teaching coordination. The concepts presented in the first half of the statistics course will be applied in the second half of the statistical programming course, which represents an immediate application of statistical concepts to the solution of practical problems. *Technical Mathematics II* completes the mathematical requirements of the curriculum and offers a basis for the third-semester course entitled *Fundamentals of Scientific Computation*. It should be noted that a 3-hour laboratory has been assigned for *Technical Mathematics II*. This is done so that the student immediately becomes aware of the significance of mathematics to scientific programming and recognizes the close relationship between all courses within the curriculum. *Graphical Representation* has the objective of presenting to the student methods of data representation and interpretation. Numerical control, for example, is a segment of the curriculum appearing in the last semester where the techniques of drafting and design are extremely important in transferring schematic data to computer input.

After the completion of the first year, the student will have gained knowledge and skills sufficient for many industrial programming applications using the FORTRAN language and statistical concepts. The second year is devoted to developing an awareness of the many fields of application and, through laboratory experience, acquainting the student with a method of solution. Beyond these objectives, effort will be expended in acquiring knowledge which fosters ingenuity and creativity and instills within the student a concept of "no best way."

Fundamentals of Scientific Computation presents to the student computer applications relative to mathematical programming. The mathematical courses presented in the first year serve as a carrier of the new concepts presented in this course as well as a practical tool for the solution of computer problems. *Boolean Algebra* presents the mathematics of logic with theorem and postulate presentations oriented toward computer applications. The course *Linear Programming* offers the student an opportunity to learn, in depth, one of the disciplines used in operations research. Course structure is developed from graphical methods of solution into the simplex method and computer solution. *Industrial Organization and Management* helps the student achieve a knowledge of industry and its organization. It emphasizes the traits and qualities of leadership which are expected in those who look forward to promotion into executive or supervisory positions.

In the fourth semester, the student begins to bring together the seemingly unrelated concepts of mathematical computation and *Programming for Engineering Applications*. There are, of course, too many singular engineering applications to present even a fair representation within one course. Rather than offer a confusing array of engineering feats made possible by the automatic digital computer, emphasis has been directed toward four major areas. This will allow sufficient time in each section for the student to grasp the basic fundamental essentials which are necessary for the application of the procedure. *Introduction to Operations Research* is dedicated to the concept that a successful technician in scientific data processing must know the fundamental principles involved in the application of the most modern concepts in problem solution. This course presents an overview of the techniques and tools employed in operations research. The approach is directed toward the understanding of general aspects, term definitions, and the observance of the proper relationships between methods of solution and problem characteristics. The course *Field Project* is highly personalized in the sense of individual student activity and interest. The student is afforded an opportunity to explore in depth a region of computer applications which has excited his interest. The instructor will assume responsibility as a guide and offer suggestions necessary to keep the problem within the realm of practicality. The final student accomplishment will be the documentation of problem definition and procedure for solution.

The courses suggested in this guide constitute only one approach to instruction in a field of employment which is in a state of constant transition. The instructor is offered the challenge and responsibility to maintain constant vigilance on the development of new techniques and procedures and to offer curriculum modification where justified.

Suggested Continuing Study

A 2-year curriculum must concentrate on the primary needs of mathematics, science, and the related knowledge and skills in the technical specialty necessary to prepare the student for employment upon graduation.

Obviously, a 2-year program cannot cover in depth all of the subjects which are pertinent to the technology; certain important related subjects may be only casually discussed. Further, the graduate may obtain work in applications so new that adequate coverage in the training program has not yet been developed, especially in such a recently created, rapidly expanding, and changing field as scientific data processing.

For these reasons, some form of continuation of study for graduates of this program is desirable. The student can keep abreast of the technical developments in his special field by reading current literature related to the technology, by attending meetings of scientific and technical societies, and by studying on his job. However, such study tends to build on the organized technological base provided by the curriculum he studied. Formal continuation of supplementary courses provides the most efficient and practical means for the graduate technician to add important related areas of knowledge and skill to broaden the base of his initial education. Formally organized courses have the advantage of systematic arrangement of subject matter, disciplined and competent teaching, and class discussions. They may be scheduled for evening or Saturday hours outside of the working day.

Some suggested continuation or extension courses for graduates of this program curriculum include the following subjects: Advanced Mathematics, Basic or Advanced Physical Science Subjects, Basic or Advanced Life Science Subjects, Engineering and Related Subjects, Cost Estimating, Queuing Techniques, Decision Theory, Operations Research, Simulation Techniques, and other technical courses indicated as desirable by local industry.

COURSE OUTLINES

The courses which follow are intended to suggest the content which might be taught in the curriculum. The materials suggested provide a practical and attainable coverage of the field and have been reviewed by experienced instructors in successful scientific data processing educational programs and by experts representing employers of skilled data processing technicians.

It is expected that these materials will be modified in some measure to fill the needs defined by local advisory committees and to take advantage of the special interests and capabilities of the teaching staff in any particular institution, but the implied level, quality, and completeness of the program should not be compromised.

At the end of each course is a list of text and reference materials. Each should be analyzed for its content and pertinency; and new and more suitable ones should be substituted if they are available. The information needed to cover a particular course in technician-educating curriculums, particularly the technical specialty courses, is almost never available in one textbook; hence the multiple listing of references. They usually should be considerably augmented by the current materials from manufacturers, trade journals, technical societies, and suppliers of apparatus and services in the special field of applied science being studied.

It is expected that the experienced instructor will make liberal use of charts, slides, models, samples, and specimens which illustrate special technical aspects of the subject. These usually are accumulated from the experience of previous laboratory or lecture preparations of the instructor, and should be updated regularly when new developments require it. They are too specific for any attempt to be made to list them in this suggested guide.

The laboratory sessions suggested in the curriculum outline and in the course descriptions are not necessarily intended to be a single session, but rather total hours of laboratory per week, to be scheduled in reasonable and effective increments. For example, a 6-hour laboratory total per week for a course might be scheduled as three 2-hour sessions or two 3-hour sessions, or any other division of laboratory time that seems appropriate.

The descriptions of laboratory exercises in this guide are only examples which represent models. They should not be interpreted as the total plan of laboratory work. The instructor is expected to design laboratory assignments according to the needs of his students and the requirements of the material and make use of current literature and other sources at his disposal to insure the effectiveness of laboratory exercises.

INTRODUCTION TO DATA PROCESSING

Hours Per Week

Class, 3; laboratory, 6

Description

This course presents a general introduction to the concepts and basic features of electronic computers. The major emphasis is directed toward a general coverage of the field of computers and is not restricted to a specific computer. Computer language is presented only as a carrier of concepts and further language development will be presented in later courses as required. Caution must be exercised by the instructor to insure that disproportionate time is not expended on topics of popular interest. The student will have ample time to pursue individual interests in the seminar course which is presented concurrently with this course.

Major Divisions

	Hours Class	Hours Laboratory
I. Evolution of Data Processing Systems	3	0
II. Classification of Computers	2	0
III. Common Features of Data Processing Systems	2	0
IV. Computer Applications	5	0
V. Types and Characteristics of Data Representation	6	10
VI. Computer Internal Operation	3	4
VII. Programming Concepts	6	18
VIII. Computer Operation	2	6
IX. Introduction to Problem-oriented Languages	3	0
X. Basic Elements of FORTRAN	5	32
XI. Basic Elements of COBOL	5	26
XII. Computer Evaluation Techniques	3	0
XIII. Future Developments	3	0
Total	48	96

I. Evolution of Data Processing Systems
- A. Units of instruction
  - 1. Mechanical calculators
    - a. Abacus
    - b. Slide rule
    - c. Adding machine
    - d. Difference engine
    - e. Calculating machine
  - 2. Electro-mechanical tabulation
    - a. Punched-card machines
    - b. MARK I—Automatic Sequence Controlled Calculator
  - 3. Electronic computers
    - a. ENIAC—Electronic Numerical Integrator and Calculator
    - b. EDVAC—Electronic Discrete Variable Automatic Computer
    - c. UNIVAC—Universal Automatic Computer
- B. Laboratory projects

II. Classification of Computers
- A. Units of instruction
  - 1. Analog—Digital
  - 2. Automatic—Semiautomatic
  - 3. General Purpose—Special Purpose
  - 4. Binary—Decimal
  - 5. Fixed Word Length—Variable Word Length
  - 6. Business—Scientific
- B. Laboratory projects

III. Common Features of Data Processing Systems
- A. Units of instruction
  - 1. Input units
    - a. Card reader
    - b. Paper tape reader
    - c. Console typewriter
    - d. Magnetic tape reader
    - e. Magnetic ink reader (MICR)
    - f. Optical character reader
  - 2. Memory units
    - a. Magnetic core
    - b. Magnetic disc and drum
  - 3. Central processing unit (CPU)
    - a. Arithmetic units
    - b. Logic unit
    - c. Primary memory unit
  - 4. Output units
    - a. Printer

b. Card punch
c. Console typewriter
d. Graph plotter
e. Display device
f. Paper tape punch
g. Magnetic tape unit

B. Laboratory projects

IV. Computer Applications

A. Units of instruction

1. Typical business applications
   a. Payroll
   b. Customer accounting
   c. Inventory accounting
   d. Production scheduling
   e. Quality control
2. Information systems
   a. Real-time systems
   b. The total system concept
   c. Information retrieval
3. Management science techniques
   a. Linear programming
   b. Critical path (CPM/PERT)
4. Scientific applications
   a. Medical diagnosis
   b. Road building
   c. Weather prediction
   d. Space computing
   e. Engineering problem solution
5. System simulation
   a. Weapons simulation
   b. Economic simulation
   c. Marketing simulation
   d. Computer-assisted instruction
6. Computer research and the humanities
   a. Language translation
   b. Literary stylistic analysis

B. Laboratory projects

V. Types and Characteristics of Data Representation

A. Units of instruction

1. Numbering systems
   a. Conversion techniques
   b. Arithmetic operations
2. Hollerith code
3. Memory code
   a. Seven-bit alphameric (BCD)
   b. Six-bit numeric
4. Paper tape code
   a. Eight-channel
   b. Five-channel
5. Magnetic tape code
   a. Seven-bit
   b. Binary

B. Laboratory projects

1. Accept a sample of alphamerical information (a few words and numbers are sufficient) and indicate how the information would be represented in the following codes: Hollerith, binary (six-bit numeric—BCD), binary (seven-bit alphameric), eight-channel and five-channel paper tape, seven-bit and binary magnetic tape.
2. Verify as many of the codes as possible by use of laboratory equipment. Have one form of coded medium processed for interpretation by the computer. The instructor will demonstrate this phase of the laboratory experiment and will cause identical outputs on different media to be created by the system to further verify coding schemes.

VI. Computer Internal Operation

A. Units of instruction

1. Computer circuitry
   a. Pulse-shaping circuits
   b. Logic circuits
   c. Bit storage (flip-flop)
   d. Timing circuits
   e. Adders
   f. Registers
2. Functional assemblies
   a. Decimal-to-binary converter (encoder)
   b. Binary-to-decimal converter (decoder)
   c. Accumulator
   d. Comparator
3. Memory characteristics
   a. Address concept
   b. Computer word—fixed and variable
4. Comparison of memory size
5. Computer operating cycle
   a. Instruction time
   b. Execution time
   c. Access time
6. Discussion of computer design
   a. Timing
   b. Information transfer
   c. Arithmetic operations
   d. Internal data representation

B. Laboratory projects

1. Obtain from the instructor a program and data developed to illustrate register contents and their interrelationship.
2. Process the program through the system and analyze register content for each instruction and data used.

VII. Programming Concepts
- A. Units of instruction
  1. Program characteristics
     a. Elementary step concept
     b. Sequential action
     c. Instruction modification
  2. Problem definition techniques
     a. Diagramming symbols
     b. Techniques of flow-charting
     c. Decision tables
  3. Computer instruction characteristics
     a. Single-address system
     b. Double-address system
     c. Triple-address system
  4. Programming languages
     a. Machine language
     b. Symbolic language
     c. Macro instructions
     d. Problem-oriented languages
  5. Programming aids
     a. Library routines
     b. Utility programs
     c. Report generators
     d. Users group programs
     e. Conversion programs
- B. Laboratory projects
  1. Design a flow chart to determine the middle numerical value of three variables punched in a unit record card. Print the middle numerical value only and branch to read another card. Assume that no two values of the three compared fields are equal.
  2. Code the program in machine language and process on the computer, using data of every possible combination of relationships.
  3. Process a users group program which demonstrates computer procedure, i.e., a demonstration-type program.

VIII. Computer Operation
- A. Units of instruction
  1. Programming in a symbolic language
     a. Instruction development from flow chart
     b. Production of source statements
     c. Mechanics of program assembly
     d. Execution of object program
  2. Debugging techniques
     a. Desk checking
     b. Trial run with test data
     c. Diagnostic procedures
  3. Program execution
     a. Computer console orientation
     b. Loading the program
     c. Starting the program
     d. Controlled and uncontrolled stops
     e. Analysis of register content
- B. Laboratory projects

  Write and execute a program written in symbolic language designed to print the middle numerical value of three variables punched in a unit record card. Assume that no two values of the three compared fields are equal. Transfer the source statements to acceptable input media; assemble the program and execute using representative data.

IX. Introduction to Problem-oriented Languages
- A. Units of instruction
  1. Basic concepts of problem orientation
     a. Development of compilers
     b. Characteristics of a compiler system
     c. Using a compiler
  2. Operation of a compiler
     a. Language specification
     b. Translator routine
     c. Subroutines
     d. Polish notation (operator notation)
  3. Compiler evaluation
     a. Programming costs
     b. Running time
     c. Flexibility
- B. Laboratory projects

X. Basic Elements of FORTRAN
- A. Units of instruction
  1. Development of FORTRAN
  2. Overview of FORTRAN
  3. FORTRAN program preparation
     a. Problem definition
     b. Flow chart
     c. Development of source statements
  4. FORTRAN program execution
     a. Loading the compiler
     b. Processing of source statements

c. Console options (control switches)
d. Execution of object program

B. Laboratory projects
1. Write and execute a FORTRAN program to demonstrate the use of FORTRAN I/O statements exercising the various output options.
2. Write and execute a FORTRAN program utilizing the decision abilities of the IF statement.
3. Write and execute a FORTRAN program which employs addition, subtraction, multiplication, division, and exponentiation. Obtain output in various formats and verify their validity.

XI. Basic Elements of COBOL
A. Units of instruction
1. Development of COBOL
2. Overview of COBOL
3. COBOL language structure
a. Conventions
b. Coding format
c. Indentation
d. Sections and paragraphs
e. Characters, words, and sentences
f. Qualifiers and subscripts
4. Mechanics of COBOL program execution

B. Laboratory projects
1. Write a COBOL program to read 200 employee payroll records consisting of name, hours worked, and date. Calculate the gross pay using a rate of \$3.18 per hour and develop a printed report containing the name and gross pay.
2. Modify the above program to calculate deductions at the rate of 7 percent for all of gross pay in excess of \$92.46.

XII. Computer Evaluation Techniques
A. Units of instruction
1. Feasibility study
a. Establishment of evaluation criteria
b. Description of process objectives
c. Tentative system selection
2. Selection of computer equipment
a. Manufacturer's proposal
b. Final equipment selection
3. Methods of computer financing
a. Rental
b. Lease
c. Purchase

B. Laboratory projects

XIII. Future Developments
A. Units of instruction
1. Memory devices
a. Thin-film
b. Sheet-ferrite
c. Superconductive memory
d. Associative or search memory
2. Internal circuits
a. Zenor diode
b. Tunnel diode
c. Monolithic integrated circuitry
d. Cryogenics
3. Programming techniques
a. Standardization of compiler languages
b. Improvements in program media
c. Increased numbers of software packages

B. Laboratory projects

Texts and References

AMBER and AMBER. *Anatomy of Automation.*
ARBIB. *Computers and Computing.*
ARDEN. *An Introduction to Digital Computing.*
BUCHHOLZ. *Planning a Computer System.*
CRABBE. *Automation in Business and Industry.*
CUTLER. *Introduction to Computer Programming.*
DAVIS. *An Introduction to Electronic Computers.*
DESMONDE. *Computers and Their Uses.*
———. *Real-time Data Processing Systems: Introductory Concepts.*
GREGORY and VAN HORN. *Automatic Data Processing.*
HULL. *Introduction to Computing.*
WILKES. *Automatic Digital Computers.*

TECHNIQUES OF REAL-TIME AND REMOTE COMPUTATION

Hours Per Week

Class, 3; laboratory, 2

Description

This course is designed to offer the student an opportunity to gain a general understanding and an appreciation of the capabilities and limitations of recent developments in computer usage. The course progresses from the stage of hardware considerations through basic concepts of operating systems and data management techniques.

Major Divisions

	Hours Class	Hours Laboratory
I. Configurations for Time Sharing and Remote Computations	17	6
II. Operating Systems	16	12
III. Job Control Languages	10	8
IV. Data Management	10	6
Total	53	32

I. Configurations for Time Sharing and Remote Computation

A. Units of instruction

1. Transmission of quantitative data
   a. Analog and digital transmission
   b. Considerations for polling and response time
   c. I/O queuing and priorities
2. Time sharing
   a. Program process time
   b. Multiple processing with I/O interrupt system
   c. Considerations for memory protection
   d. Terminal operating techniques
3. Hardware considerations
   a. Availability
   b. Limitations
   c. Economics

B. Laboratory

1. Identify the elements of a telecommunication system configuration and make a flow diagram representing communication paths.
2. Defend the choice of hardware on the basis of system capabilities, software availability, and costs.

II. Operating Systems

A. Units of instruction

1. Definition and desirability of an operating system
2. Philosophy of operating systems
   a. Modular design
   b. Multiple language and batch processing systems
   c. Telecommunications and real-time systems
   d. Multiple program systems
   e. Partitioning of memory
   f. Storage protection
3. System organization
   a. Assemblers
   b. Macro language
   c. Utility programs
   d. Supervisor
   e. Job control processor
   f. Systems library
4. Nucleus or basic supervisor
   a. Input-output (I/O) control routines
   b. End-of-job routine
   c. Communications region and assignment table
5. Transitional supervisor
   a. Physical and logical IOCS
   b. Initiation and termination
6. Control programs
   a. Data management
   b. Job management
   c. Task management
7. Relocatability
8. Linkage editor
   a. Function
   b. Source and object module
   c. Load module

B. Laboratory project

1. Submit a written definitive report on the selection of an operating system based on a hardware configuration and price range assigned by the instructor.
2. Develop a description of an operating system required for a computer instal-

lation. Itemize and describe facilities for storage procedures, and operations for utility programs.

III. Job Control Languages (units of instruction)

A. Job control languages (JCL)

B. Job card
   1. Format and parameters
   2. Options

C. Execute card
   1. Format and parameters
   2. Options
   3. Compile load module
   4. Cataloged procedure

D. Data definition statements (DD)
   1. Format
   2. Fields
   3. Parameters

E. Delimiter statement
   1. Function
   2. Format

F. Standard cataloged procedures
   1. Options
   2. Overriding procedures

G. Standard I/O DD statements

H. Tape drive
   1. Sequential
   2. Speed
   3. Write, read
   4. Parity check

I. Disk drive
   1. Concept
   2. Random access
   3. Track and space
   4. Arm movement
   5. Time considerations
   6. Read, write, and seek
   7. Overflow

J. Object time work files
   1. DD statement
   2. Parameters
   3. Unit
   4. Label
   5. Space
   6. Data control block

IV. Data Management

A. Units of instruction
   1. Introduction
      a. Data set control
      b. Data access
      c. Data sets
   2. Data set cataloging
      a. Definition of catalog
      b. Control volumes
      c. Structure of catalog and volume index
      d. Cataloging and generating data sets
      e. Cataloging generated data groups
   3. Data set security protection
   4. Data set storage and volume
      a. Data storage on direct-access volumes
      b. Volume initiation
      c. Storage of a data set
      d. Allocation by blocks, by track, or cylinders
   5. Data set record formats
      a. Logical records
      b. Record blocking and formats
      c. Fixed and variable length
   6. Data set organization
      a. Sequential and partitioned organization
      b. Space allocation
      c. Directory
      d. Index sequential organization
      e. Insertion of records
      f. Overflow area
   7. Direct organization
      a. Definition of direct organization
      b. Insertion of records
   8. Telecommunications organization
   9. Data set definition
      a. Data control block
      b. Data definition statement
      c. Data set labels
   10. Data access methods
      a. Macro instruction language
      b. Language for queued and basic access
   11. Classification of access methods
      a. Execute channel program
      b. Use of open and close
   12. Access methods for sequential data sets
      a. Data format
      b. Physical devices
      c. Classical scheduling
   13. Basic sequential access method
      a. Record formats
      b. Buffering considerations
      c. Macro instructions
      d. Programming notes

14. Basic partitioned access method
    a. Record formats
    b. Macro instructions
    c. Programming notes
    d. Creating a partitioned data set
    e. Concatenation of partitioned data set
    f. Basic partitioned access method compatibility
15. Basic indexed sequential access method
    a. Record formats
    b. Buffering considerations
    c. Macro instructions
    d. Exceptional conditions
    e. Exclusive control
    f. Reorganizing an indexed sequential data set
    g. Programming notes
16. Basic direct access method
    a. Record formats
    b. Buffering considerations
    c. Macro instructions
    d. Exceptional conditions
    e. Exclusive control
    f. Creating direct data sets
    g. Format fixed records with and without keys
    h. Formats for variable and unblocked records
17. Space and time requirements demanded by each version of data management technique

B. Laboratory
    1. Add a user program to the job library.
    2. Use several access devices passing data sets from one job step to the next.
    3. Use sort-merge utility program as needed in a problem program.
    4. Write and execute a program that uses sequential and indexed techniques in referencing direct access devices.

Texts and References

AMBER and AMBER. *Anatomy of Automation.*

BUCHHOLZ. *Planning a Computer System.*

CLARK. *Introduction to Automatic Control Systems.*

DESMONDE. *Real-time Data Processing Systems: Introductory Concepts.*

FISHER and SWINDLE. *Computer Programming Systems.*

FLORES. *Computer Software: Programming Systems for Digital Computers.*

LADEN and GILDERSLEEVE. *System Design for Computer Applications.*

MACHOL and GRAY. *Recent Developments in Information and Decision Processes.*

MARTIN. *Programming Real-time Computer Systems.*

POPELL. *Computer Time-sharing: Dynamic Information Handling for Business.*

SCHMIDT and MEYERS. *Introduction to Computer Science and Data Processing.*

STATISTICAL PROGRAMMING AND THE LIFE SCIENCES

Hours Per Week

Class, 3; laboratory, 6

Description

This course is an introduction to problem-solving in the applied life sciences field by the use of electronic data processing methods and equipment. The course is divided into two sections. The first section contains a discussion of the FORTRAN language and general procedures which must be used to solve scientific problems. The FORTRAN programming language developed in this course will develop concepts and programming abilities which the student will use in the remainder of the programming activities which follow throughout the rest of this curriculum. The second section presents mathematical and statistical techniques which illustrate and teach the student how FORTRAN programming can be used to solve problems in the life sciences.

Major Divisions

	Hours	
	Class	*Laboratory*
I. The FORTRAN Language	18	40
II. Life Science Applications	30	56
Total	48	96

I. The FORTRAN Language
  A. Units of instruction
    1. Definition of FORTRAN and general applications
    2. FORTRAN coding form
    3. FORTRAN statement rules for general data operations
      a. READ statement
      b. PRINT statement
      c. END statement
      d. FORMAT specification
      e. DIMENSION statement
      f. Names of floating- and fixed-point variables
      g. FORMAT—X specification
    4. FORTRAN statements for arithmetic operations
      a. Arithmetic symbols
      b. Arithmetic expressions
      c. Order of operations
      d. Fixed- and floating-point constants
      e. E-notation
      f. FORMAT—E specification
      g. Mode of an expression
      h. FORMAT—I specification
      i. FORMAT—H specification
      j. Arithmetic function
    5. FORTRAN statements for control operations
      a. GO TO statement
      b. Computed GO TO statement
      c. IF statement
      d. IF (SENSE SWITCH N) statement
      e. STOP statement
      f. PAUSE statement
    6. FORTRAN statements for processing arrays and matrices
      a. Subscripts
      b. Arrays
      c. Program loop
      d. DO statement
      e. CONTINUE
      f. Input of arrays
    7. FORTRAN statements for subprogram operation
      a. Library functions
      b. Function statement
      c. RETURN statement
      d. SUBROUTINE statement
      e. CALL statement
      f. COMMON statement
    8. FORTRAN processing procedures
      a. Development of source statement
      b. Processing source program
      c. Controlled options
      d. Error routine
      e. Processing object program
  B. Laboratory
    1. Write and execute FORTRAN I/O programs which demonstrate the application of available hardware and each of the available formats.
    2. Write and execute FORTRAN programs which illustrate the order of arithmetic operations. Use addition, subtraction, multiplication, division, and exponentiation.

3. Write and execute FORTRAN programs to illustrate the function of each of the control statements.
4. Write and execute FORTRAN programs to read an input array, perform arithmetic operations, and output solutions.

II. Life Science Applications
 A. Units of instruction
  1. Data screening
   a. Problem statement procedures
   b. Input preparation
   c. Output design
   d. Program process procedure
   e. Examples of problem type
  2. Correlation
   a. Application of correlation in the life sciences
   b. Limitation of correlation interpretation
   c. Mathematical discussion
   d. Specific problem statement
   e. Input considerations
   f. Output design
   g. Solution procedure
   h. Significance of solution
  3. Linear regression
   a. Applications of regression in the life sciences
   b. Definition and interpretation of the regression coefficient
   c. Mathematical discussion
   d. Specific problem statement
   e. Considerations for input
   f. Output design
   g. Solution procedure
   h. Interpretation of results
  4. Chi-square test
   a. Application of chi-square in the life sciences
   b. Cautions in cell combinations
   c. Mathematical discussion
   d. Specific problem statement
   e. Input considerations
   f. Output design
   g. Solution procedure
   h. Interpretation of results
  5. Analysis of variance
   a. Application of analysis of variance in the life sciences
   b. Definition and interpretation of analysis of variance
   c. Mathematical discussion
   d. Specific problem statement
   e. Input consideration
   f. Solution procedure
   g. Interpretation of results
  6. Factor analysis
   a. Application of factor analysis in the life sciences
   b. Definition and interpretation of the principle-components analysis
   c. Definition and interpretation of rotational schemes
   d. Input consideration
   e. Output design
   f. Solution procedure
   g. Interpretation of results
  7. Miscellaneous computer applications in life sciences
   a. Computer-aided diagnosis
   b. Computer-assisted instruction
   c. Language translation
   d. Analysis of optimum-mix procedures from economic point of view
   e. Analysis of election prediction methods

 B. Laboratory
  1. Design and execute a FORTRAN program to accept eight three-digit variables and print a matrix of intercorrelation.
  2. Design and execute a FORTRAN program, using the same data as in Laboratory Exercise No. 1, which will produce the regression coefficient for each variable on every remaining variable.
  3. Design and execute a general purpose program for chi-square. Design the program in such a manner that cell combination is automatic and table size is variable.
  4. Design and execute a program to perform an analysis of variance on test data used for Laboratory Exercise No. 1.
  5. Design and execute a program which which will accept three-digit variables representing five levels of factor "A" and two levels of factor "B." Calculate the sums of squares between treatments, "A"—Main effect, "B"—Main effect, A x B interaction, within, and

total. Have output in standard form for analysis of variance table with calculated F-values and proper headings.

6. Design and execute a program which will accept the correlation matrix from Laboratory Exercise No. 2 and perform a factor analysis. Have the program generate the percentage of contribution of each factor toward total variability and factor loadings.

Texts and References

BLALOCK. *Social Statistics.*

BOWKER and LIEBERMANN. *Engineering Statistics.*

DAVIS. *An Introduction to Electronic Computers.*

FREUND. *Mathematical Statistics.*

GOLDE. *FORTRAN II and IV for Engineers and Scientists.*

———. *FORTRAN IV: Programming and Computing.*

GUENTHER. *Analysis of Variance.*

HAYES. *Statistics for Psychologists.*

WEISS. *Statistical Decison Theory.*

WINE. *Statistics for Scientists and Engineers.*

FUNDAMENTALS OF SCIENTIFIC COMPUTATION

Hours Per Week

Class, 3; laboratory 6

Description

This course is designed to present to the student those topics in numerical analysis and allied mathematical subjects that are most relevant to the use of digital computers in the solution of engineering and scientific problems. Each major topic is presented in terms of computer applications and is supported by extensive laboratory projects. The course should present working definitions of all topics when they are first encountered and instruct the student how to obtain practical computer solutions, rather than dwell on theoretical concepts of mathematics.

Major Divisions

	Hours Class	Hours Laboratory
I. Review of Basic Notations and Concepts	3	5
II. Fixed- and Floating-point Notation	3	5
III. Basic Boolean Operations	3	2
IV. Precision and Significance	6	3
V. Types of Errors in Numerical Solutions	8	4
VI. Concepts of Algorithms and Iteration	6	15
VII. Computer Application to Matrix Solutions	5	15
VIII. Derivatives and Integrals	4	14
IX. Differential Equations and Computer Solutions	6	17
X. Application of Package Programs for Scientific Computation	4	16
Total	48	96

I. Review of Basic Notations and Concepts
   A. Units of instruction
      1. Kinds of numbers
         a. Integers
         b. Irrational numbers
         c. Real numbers
      2. Variables and constants
      3. Subscripts and arrays
         a. Single subscripts; one-dimensional arrays
         b. Monotonic ordering
         c. Multiple subscripts; multidimensional arrays
      4. Arithmetic and geometric progressions
      5. Infinite processes
         a. Infinite sequences
         b. Infinite series
         c. Infinite arithmetic and geometric progressions
      6. Miscellaneous definitions
         a. Absolute values
         b. Factorial
         c. Necessary and sufficient conditions
      7. Functional notation
      8. Graph of a function
      9. Exponents
      10. Review of logarithms (base 10)
         a. Laws of logarithms
         b. Use of logarithm tables
   B. Laboratory
      1. Construct a flow chart and a FORTRAN program that will read in a linear array of numbers: $x_1, x_2, \ldots, x_n$, sort them into ascending order, and print them out in sorted form.
      2. Consider the infinite geometric series $1, \frac{1}{2}, \frac{1}{4}, \ldots, \frac{1}{2}i$, where $i = 0, 1, 2, \ldots, n$. Construct a flow chart and a FORTRAN program to sum this series until the terms s_n and s_{n+1} differ from some prescribed e.
         Note: $S_n = 1 + \frac{1}{2} + \frac{1}{4} + \ldots, \frac{1}{2}n$; $1S_{n+1} - S_n 1 < e$. Compare the results with the analytic results obtained by closed-form solution.

II. Fixed- and Floating-point Notation
   A. Units of instruction
      1. Fixed-point notation
         a. Advantages of fixed-point notation programming
         b. Disadvantages of fixed-point notation and programming

2. Floating-point notation
   a. Advantages of floating-point notation and programming
   b. Disadvantages of floating-point notation and programming

B. Laboratory

Using a FORTRAN program calculate 25! What are the advantages of floating-point arithmetic? If this problem could be done using fixed or integer arithmetic, what would be the advantage of this over floating point?

III. Basic Boolean Operations

A. Units of instruction
1. Fundamental operations
   a. NOT
   b. AND
   c. OR
2. Truth tables
3. Development of a Boolean expression from a truth table
4. Program development from Boolean expressions

B. Laboratory

Construct a logical circuit for adding binary digits using AND, OR, NOT black boxes.

+	0	1
0	00	01
1	01	10

IV. Precision and Significance

A. Units of instruction
1. Definition of significance
2. Definition of precision
3. Absolute error in machine representation
4. Relative error in machine representation
5. Considerations concerning increase in machine speed
6. Estimate of proper word length for a fixed-word-length computer
   a. Effects of word base
   b. Effects of speed
   c. Relationship between speed, base, and word positions

B. Laboratory

Using $X - \frac{X^3}{3!}$ as an approximation for sin X, find the absolute error and relative error in using this approximation for $X = .1$

V. Types of Errors in Numerical Solutions

A. Units of instruction
1. Mathematical approximation to the physical situation
2. Inherent errors in the input
3. Truncation error
4. Roundoff error
   a. Cause
   b. Effects on computer design
5. Reduction of roundoff errors
   a. Multiple precision arithmetic
   b. Timing effects of double precision arithmetic
   c. Reading order of arithmetic operations to reduce error
6. Need for caution because of roundoff errors

B. Laboratory

Given the set of simultaneous equations $1.00 X + 0.65 Y = 4.00$, $2.95 X + 2.00 Y = 12.00$, find the solution $\bar{x}, \bar{y}$. Find the maximum and minimum values for $\bar{x}, \bar{y}$ if the coefficients are accurate within $\pm .005$.

VI. Concepts of Algorithms and Iteration

A. Units of instruction
1. Definition of algorithm
2. Computer application of algorithms
   a. Numerical examples
   b. Non-numerical examples
3. Definition of iterative procedures
   a. Advantages
   b. Disadvantages
   c. Examples of iterative procedures

B. Laboratory
1. Write and execute a FORTRAN program using the iteration formula for finding the square root of 12 accurate to seven places. Note: Iteration formula for finding the square root of a number is:

$$x_i + 1 = \frac{1}{2}\left(x_i + \frac{A}{x_i}\right).$$

A few of the steps are:

$$x_1 = \frac{1}{2}\left(x_0 + \frac{A}{x_0}\right)$$

$$x_2 = \frac{1}{2}\left(x_1 + \frac{A}{x_1}\right)$$

$$x_3 = \frac{1}{2}\left(x_2 + \frac{A}{x_2}\right)$$

$$\vdots$$

$$\vdots$$

$$x_i + 1 = \frac{1}{2}\left(x_i + \frac{A}{x_i}\right)$$

2. Design a flow chart, then code in FORTRAN and execute a program to evaluate the polynomial $f(x) = a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x^1 + a_o$ where the values of the coefficient $a_0, a_1 \ldots, a_5$ are to be read into the computer and the value of f(x) is to be printed.

VII. Computer Application to Matrix Solutions
- A. Units of instruction
  1. Brief review of matrices
     - a. Term definitions
     - b. Basic operations
     - c. Application of matrix algebra
  2. Programming considerations in matrix computations
     - a. Storage requirements
     - b. Number of computations required
  3. Miscellaneous I/O considerations
     - a. Case of sufficient storage
     - b. Case of insufficient storage
     - c. Processing time
  4. Criteria for selecting fixed- or floating-point arithmetic
- B. Laboratory
  1. Draw a flow chart and code in FORTRAN a program to read into computer memory two matrices (A and B). Develop the product A·B and print the answer matrix.
  2. Draw a flow chart and code in FORTRAN a program to accept an M x N correlation matrix and by Hoteling's iterative process perform a factor analysis.

VIII. Derivatives and Integrals
- A. Units of instruction
  1. Definition of a derivative
  2. Geometric interpretation of a derivative
  3. Derivatives of higher order and partial derivatives
  4. Approximations of the derivative
  5. Definition of an integral
  6. Graphical representation of an integral
  7. Geometric interpretation of an integral
- B. Laboratory
  1. Write and execute a FORTRAN program to evaluate $\int_0^1 ydx$ where $y = \frac{1}{1 + x^2}$ using $\Delta x = .05$.
  2. Write and execute a FORTRAN program to evaluate $\int_0^4 f(x)\,dx$ for each of the following integrands: (a) $f(x) = 1 + x$; (b) $f(x) = 1 + x^2$; (c) $f(x) = 1 + x^3$; (d) $f(x) = 1 + x^4$.

IX. Differential Equations and Computer Solutions
- A. Units of instruction
  1. Definition of a differential equation
     - a. Ordinary differential equation
     - b. Partial differential equation
  2. Examples of physical problems leading to differential equations
     - a. Population change
     - b. Computation of projectile path
  3. Numeric methods for differential equation solution
     - a. Euler's Method
     - b. Runge-Kutta Fourth-order Method
- B. Laboratory
  1. Design and execute a FORTRAN program to solve the following problem: Find the velocity at the end of 50 seconds of a body with an initial mass of 200 slugs that is accelerated by a constant force of 2,000 pounds. The mass decreases at a rate of 1 slug/second. The body is at rest at $t = 0$. The differential equation is $dv/dt = 2{,}000/(200\text{-}t)$.
  2. Modify the program above to accept varying values for constant force (xxxx); varying values for decrease of mass at a rate (x).

X. Application of Package Programs for Scientific Computation
- A. Units of instruction
  1. Source of programs
     - a. Equipment manufacturers
     - b. User groups
  2. Advantages of package programs
  3. Disadvantages of package programs
  4. Procedure for program submission

5. Special precautions in using packaged programs

B. Laboratory

Laboratory exercises for this division will depend upon the types and quality of available programs. In general, programs should be selected which are representative of individual student interest. Each laboratory assignment should be to obtain, evaluate, and, if necessary, to modify an existing program to accomplish a stated objective.

Texts and References

ADAMS. *Applied Calculus.*

ARNOLD. *Logic and Boolean Algebra.*

BROOKS and IVERSON. *Automatic Data Processing.*

FLORES. *Computer Programming: General Digital Computer Programming Principles.*

———. *Computer Software: Programming Systems for Digital Computers.*

GOLDE. *Fortran II and IV for Engineers and Scientists.*

GROVE. *Brief Numerical Methods.*

IVERSON. *A Programming Language.*

LAPIDUS. *Digital Computation for Chemical Engineers.*

LARSSON. *Equalities and Approximations: With Fortran Programming.*

McCORMICK and SALVADORI. *Numerical Methods in Fortran.*

McCRACKEN and DORN. *Numerical Methods and Fortran Programming.*

SAGAN. *Integral and Differential Calculus.*

SALVADORI and BARON. *Numerical Methods in Engineering.*

STANTON. *Numerical Methods for Science and Engineering.*

LINEAR PROGRAMMING

Hours Per Week

Class, 3; laboratory, 6

Description

This course is designed to present the basic concepts of linear programming techniques and objectives and to identify the kind of problems which can be solved by linear programming within the field of scientific management techniques and operations research. The course begins with graphical methods of problem solving and extends through the simplex method and its applications.

Major Divisions

	Hours Class	Hours Laboratory
I. Introduction to Linear Programming	4	0
II. Graphical Methods of Solution	6	12
III. Trial-and-error Method of Solution	10	15
IV. The Vector Method of Solution	6	15
V. The Simplex Method of Solution	10	24
VI. The Dual Problem	10	16
VII. Package Program Applications	2	14
Total	48	96

I. Introduction to Linear Programming
   A. Units of instruction
      1. Brief discussion of linear programming problems
         a. Defined objective
         b. Variables in competition
         c. Limited resources
         d. Variable interaction
      2. Characteristics of decision
         a. Sequential decisions
         b. Conscious decisions
         c. Managerial decisions
         d. Nonmanagerial decisions
         e. Implementation of decisions
      3. Analytical decision performance
         a. Formulation of objectives
         b. Identification of pertinent variables
         c. Formulation of available strategies
         d. Prediction of payoff
         e. Acceptance of decision
      4. Characteristics of models
         a. Physical models
         b. Analog models
      5. Mathematical models
         a. Descriptive model
         b. Predictive model
         c. Decision model
   B. Laboratory

II. Graphical Methods of Solution
   A. Units of instruction
      1. Two-dimensional case
         a. Problem statement
         b. Transformation of data into statements of inequality
         c. Transformation of inequalities to graph
      2. Graphical characteristics
         a. Recognized constraints
         b. Non-negative characteristics
         c. Development of isoprofit line
         d. Development of isocost line
      3. Three-dimensional case
         a. Similarities to two-dimensional case
         b. Graphical restriction of higher-dimensional cases
   B. Laboratory
      1. Interpret and solve a linear program consisting of two candidates and three resources by the two-dimensional graphical method. Express a rationale for the determination of an isoprofit or isocost line in terms of the objective function.
      2. Interpret and solve a linear program consisting of three candidates and three resources by the three-dimensional graphical method.

III. Trial-and-error Method of Solution
   A. Units of instruction
      1. Arbitrary trial-and-error
         a. Data transformation into inequalities
         b. Inequalities transformed into equations
         c. Addition of slack variables
         d. Simultaneous solution of derived equations

e. Optimization of the objective function
2. Systematic trial-and-error method of solution
   a. Data transformation into inequalities
   b. Inequalities transformed into equations
   c. Development of a program for initial solution
   d. Revision of initial program
   e. Continued revision
   f. Test for optimality

B. Laboratory
1. Solve laboratory exercise No. 2 in Division II by the systematic trial-and-error method.
2. Solve the following linear programming problem by the systematic trial-and-error method:

   Minimize $4x + 6y$ subject to
   $2x + 3y \geq 60$
   $4x + y \geq 40$
   and $x \geq 0, y \geq 0$.

   Give a verbal interpretation to the algebraic statements of this problem.

IV. The Vector Method of Solution

A. Units of instruction
1. Vectoral representation of the problem
   a. Structural vectors
   b. Unit vectors
   c. Constant or requirement vector
2. Design of initial program
3. Test and revision of subsequent programs
4. Test for optimization

B. Laboratory
1. Solve laboratory exercise No. 1 in Division II by the vector method and compare the different solution stages with the corresponding solution stages of the systematic trial-and-error method.
2. Solve the following problem using the vector method of solution: A contractor, upon completion of a house, discovers that 100 square feet of plywood scrap and 80 square feet of white pine scrap are in usable form for the construction of tables and bookcases. It takes 16 square feet of plywood and 8 square feet of white pine to make a table; 12 square feet of plywood and 16 square feet of white pine are required to make a bookcase. By selling the finished product, the contractor can realize a profit of \$5 on each table and \$4 on each bookcase. Maximize the profit function.

V. The Simplex Method of Solution

A. Units of instruction
1. Problem definition
   a. Objective(s)
   b. Identified variables
   c. Designated resources
   d. Determination of variable interaction
2. Preliminary remarks on the theory of the simplex method
3. Initial program design
   a. Definition and purpose of initial program
   b. The simplex tableaux
4. Testing for optimization
5. Revision of test programs
   a. Identification of key column
   b. Identification of key row and number
6. Development of subsequent tableaux
   a. Transformation of key row
   b. Transformation of nonkey rows
7. Recognition of the optimum program

B. Laboratory
1. Solve the following linear programming problem graphically and by the simplex method. Indicate in the graphical representation the extreme point which corresponds to each tableau of the simplex method:

   $3x + 5y \geq 15$
   $6x + 2y \geq 24$

   Maximize $2x = y$ subject to: $x \geq 0$, $y \geq 0$.
2. Solve the following linear programming problem by the simplex method:

   $8x + 3y + 4m + n \geq 7$
   $2x + 6y + m + 5n \geq 3$
   $x + 4y + 5m + 2n \geq 8$

   Maximize $3x + 4y + m + 7n$ subject to $x \geq 0, y \geq 0, m \geq 0, n \geq 0$

VI. The Dual Problem

A. Units of instruction
1. Introduction to dual theory
   a. Definition of the dual

b. Comparison between the primal problem and its dual

2. Fundamental properties of the dual problem
   a. Primal has optimum solution—dual optimum solution
   b. Procedure to determine optimum solution to the dual once determination has been made of an optimum solution to the primal
3. Applications of duality (economic interpretation)
   a. Shadow prices
   b. Efficient points
   c. Input-output analysis

B. Laboratory
1. Give the dual of the following problem in a form such that the dual variables are non-negative:

$$2x + 3y + 5z \geq 2$$
$$3x + y + 7z \geq 3$$
$$x + 4y + 6z \geq 5$$

Minimize $2x + 2y + 4z$ subject to: $x \geq 0, y \geq 0, z \geq 0$.

2. Using the duality theory, solve the following linear programming problem:

$$3x + 5y + 4z \geq 7$$
$$6x + y + 3z \geq 4$$
$$7x - 2y - z \geq 10$$
$$x - 2y + 5z \geq 3$$
$$4x + 7y - 2z \geq 2$$

Minimize $3x - 2y + 4z$ subject to: $x \geq 0, y \geq 0, z \geq 0$.

VII. Package Program Applications
A. Units of instruction
1. Source of programs
   a. User groups
   b. Equipment manufacturers
2. Advantage of package programs
3. Limitations of package programs
4. Special precautions
5. Submission of programs

B. Laboratory
Obtain package programs from user groups, etc. Process programs obtained and test with test data. Develop data into acceptable form from previous experiments and process through package programs. If necessary, modify package program for adaptability to existing system.

Texts and References

ACKOFF. *Scientific Method: Optimizing Applied Research Decisions.*

CHARNES and COOPER. *Management Models and Industrial Applications of Linear Programming.*

GARVIN. *Introduction to Linear Programming.*

GASS. *Linear Programming.*

GLICKSMAN. *An Introduction to Linear Programming and the Theory of Games.*

LLEWELLYN. *Linear Programming.*

LOOMBA. *Linear Programming.*

NAYLOR and BYRNE. *Linear Programming.*

SIMMONARD. *Linear Programming.*

SMYTHE and JOHNSON. *Introduction to Linear Programming with Applications.*

VAJDA. *An Introduction to Linear Programming and the Theory of Games.*

PROGRAMMING FOR ENGINEERING APPLICATIONS

Hours Per Week

Class, 3; laboratory, 6

Description

This course is designed to present basic concepts of computer applications to the broad field of engineering. Each major division represents a distinct and separate area of engineering applications and is designed to give the student an understanding of the versatility of the computer in solving engineering problems and an orientation to its use in the areas of application which are studied.

Major Divisions

	Hours Class	Hours Laboratory
I. Concepts of Real-time Programming	14	12
II. Numerical Control	10	28
III. Critical Path Methods	12	28
IV. Methods of Numerical Analysis	12	2^c
Total	48	96

I. Concepts of Real-time Programming
  A. Units of instruction
    1. Applications subject to real-time control
      a. American Airlines SABRE system
      b. Eastern Airlines reservation system
      c. Multiple-user computational centers
      d. Educational applications
      e. Process control
      f. Project Mercury
      g. SAGE system
      h. ZEUS antimissile system
    2. Projected uses
    3. Input characteristics of real-time systems
      a. Random nature of input data
      b. Multiprocessing concept
      c. Concept of teleprocessing
    4. Throughput characteristics
      a. Dependence upon load type
      b. Queuing concept
      c. Polling technique
      d. Terminal set restrictions
      e. Terminal interchange operation
    5. Programming considerations
      a. Overlapping of I/O with internal processing
      b. Buffer concept
      c. Data channels
      d. Trapping concept
      e. Multiprogramming scheduling
      f. Supervisory control programs
      g. Comparison of supervisory control with operational programs
      h. Functions of supervisory control
    6. Storage protection
    7. Overview of a real-time transaction
    8. Priority processing in multiuser systems
      a. Establishment of priority
      b. The mechanism of priority
      c. User key-control
    9. Planning and managing a real-time system
      a. Feasibility and systems study
      b. Problems of personnel
      c. Establishment of standards
      d. Documentation
      e. The function of coordination
    10. Future real-time applications
  B. Laboratory
  Define a possible area for real-time control and document the feasibility of operation and system requirements. The document should show the benefit of using a real-time control and processing system compared to batch processing.

II. Numerical Control
  A. Units of instruction
    1. Introduction to machine tools
      a. Definition of machine tool
      b. Drilling
      c. Turning and boring
      d. Planning and shaping
      e. Grinding
      f. Milling
    2. Typical machine tools
      a. Milling
      b. Shaper
      c. Grinder
      d. Engine lathe
      e. Turrent lathe

f. Machining center—milling, drilling, boring
3. The control of machine tools
a. Manual control
b. Cams
c. Playback tapes
d. Pattern tracing
e. Numerical
f. Comparison of control methods
4. Operation of numerical control
a. Point-to-point controllers
b. Straight-path controllers
5. Controller units
a. Reader, registers, and computer logic
b. Operational steps
6. Input to controllers
a. Punched tape
b. Magnetic tape
c. Punched cards
7. Control tape preparation
a. Manual
b. Computer
8. Computer preparation step procedure
a. From engineering document to English statements
b. From statements to tape
c. Statements are read by computer program
d. Computer calculates coordinate points
e. Coordinate data and tool operating instructions are read by post-processor
f. Computer creates specific machine tool tape
9. Functions of general purpose programs
a. Edit input statements
b. Translate input statements to numerical equivalent
10. Function of post-processor
a. Processes generalized output for a specific machine tool
b. Creates specialized machine control
11. Brief description of general processors
a. AUTOPROMPT II (1401)
b. AUTOMAP (1620)
c. AUTOSPOT (1620)
d. SPLIT (1620)

B. Laboratory

Obtain a general processor acceptable by the institutional system and program the required English statements from an engineering drawing necessary for computer calculation of coordinate points. Program the coordinate data and tool operating instructions required to create a specific machine control tape. If the machine tool is available, machine the programmed part by numerical control.

III. Critical Path Methods

A. Units of instruction
1. Definition of Critical Path Method (CPM)
2. Historical development
3. Areas of application
4. Network development
a. Events
b. Activities
c. Time estimates
5. Network computations
a. Time estimates
b. Slack
c. Critical path determination
d. Cost
6. CPM operation
a. Analysis
b. Creation of network
c. Calculation of time estimates
d. Identification of activities and events
e. Data transferred to input media
f. Data read by CPM program
g. Output considerations

B. Laboratory

Obtain a CPM processor adaptable to the institutional system and identify a problem area suitable for CPM operation. After the problems have been identified prepare a network of required events, activities, and time estimates. Transcribe the network data into an acceptable input media and process according to the CPM processor.

IV. Methods of Numerical Analysis

A. Units of instruction
1. Step procedure for problem solution
a. Problem identification
b. Mathematical description
c. Numerical analysis
d. Programming
e. Checkout
2. Applications
a. Aerodynamic design

   b. Chemical plant requirements
   c. Transmission lines
3. Techniques of numerical analysis
   a. Concept of inherent errors
   b. Truncation errors
   c. Roundoff errors
   d. Propagation of errors
4. Evaluation of functions
   a. Power series
   b. Telescoping power series
   c. Evaluation of series
5. Evaluation of equation roots
   a. Successive approximation
   b. Roots of polynomials
   c. Approximate root
   d. Complex roots
6. Evaluation of integrals
   a. Trapezoidal rule
   b. Simpson's rule
7. Simultaneous linear equations
   a. Gauss elimination
   b. Iterative methods

B. Laboratory

1. Design a flow chart and code a program in FORTRAN to solve a set of four simultaneous equations. Make the program general to the extent that data cards contain three-position fields for the coefficients and a two-position field for the constants. Print values for unknowns.
2. Draw a flow chart and write a FORTRAN program to read into memory the following table:

X	X(I)	Y	Y(I)
0.0	X(1)	.913	Y(1)
4.0	X(2)	.930	Y(2)
8.0	X(3)	.941	Y(3)
12.0	X(4)	.946	Y(4)
16.0	X(5)	.948	Y(5)
20.0	X(6)	.950	Y(6)
24.0	X(7)	.951	Y(7)
28.0	X(8)	.948	Y(8)
32.0	X(9)	.944	Y(9)
36.0	X(10)	.938	Y(10)
40.0	X(11)	.928	Y(11)
44.0	X(12)	.914	Y(12)

Design the program to perform a table lookup for the case of the argument X being exactly equal to a table entry value of X and print the corresponding value for Y. When the argument X falls between two table entries, perform linear interpolation by use of the following formula:

$$Y = y_i + \frac{(y_i + 1 - y_i) \quad (x - x_i)}{x_i + 1 - x_i}$$

Texts and References

ACKOFF. *Scientific Method: Optimizing Applied Research Decisions.*

ARBIB. *Computers and Computing.*

BUFFA. *Models for Production and Operations Management.*

CLARK. *Introduction to Automatic Control Systems.*

CLOUGH. *Concepts in Management Science.*

CRABBE. *Automation in Business and Industry.*

DESMONDE. *Real-time Data Processing Systems: Introductory Concepts.*

DUNLOP. *Automation and Technological Change.*

FLORES. *Computer Software: Programming Systems for Digital Computers.*

GOLDEN. *FORTRAN IV: Programming and Computing.*

GROVE. *Brief Numerical Methods.*

IVERSON. *A Programming Language.*

LADEN and GILDERSLEEVE. *System Design for Computer Applications.*

MACHOL and GRAY. *Recent Developments in Information and Decision Processes.*

MARTIN. *Programming Real-time Computer Systems.*

PENNINGTON. *Introductory Computer Methods and Numerical Analysis.*

POPELL. *Computer Time-sharing: Dynamic Information Handling for Business.*

SCHULTZ. *Digital Processing: A System Orientation.*

INTRODUCTIONS TO OPERATIONS RESEARCH

Hours Per Week

Class, 3; laboratory, 6

Description

This course is designed to present an overview of the data processing techniques and tools employed in operations research. The approach is directed toward the understanding of general aspects, term definition, and the observance of the proper relationships that exist between methods of solution and problem characteristics. A successful technician in scientific data processing must know the fundamental principles involved in the application of the most modern concepts in problem solution.

Major Divisions

	Hours Class	Hours Laboratory
I. A Survey of Operations Research Tools and Techniques	9	25
II. Application of Queuing Theory	9	0
III. Techniques of Simulation	9	35
IV. Game Theory	9	36
V. Applications of Operations Research	12	0
Total	48	96

I. A Survey of Operations Research Tools and Techniques
  A. Units of instruction
    1. Characteristics of operations research
      a. Definition
      b. Objectives
      c. Team concept
      d. Personnel requirements
      e. Systems of organizations
    2. Operations research models
      a. Iconic models
      b. Analogue models
      c. Symbolic models
      d. Function models
      e. Quantitative models
      f. Qualitative models
      g. Physical models
      h. Dynamic and static models
    3. Methods of deriving a model from a problem
      a. Analytical approach
      b. Numerical approach
    4. Relationship of models to objectives
      a. Minimized input value
      b. Harmony of objectives
      c. Maximized output value
      d. Suboptimization
      e. Differential maximization
    5. Specific mathematical techniques
      a. Gaming theory
      b. Linear programming
      c. Queuing theory
      d. Search theory
  B. Laboratory
    Obtain a program for an economic model from a user's group or manufacturer's program library. Analyze the program logic and determine to what extent optimization is evident. Present a program critique relative to model validity and restriction identification.

II. Application of Queuing Theory (units of instruction)
  A. Areas of application
    1. Telephone trunking systems
    2. Aircraft terminal traffic
    3. Harbor congestion
    4. Toll booths
    5. Production flow
    6. Hospital emergency rooms
    7. Machine repair problems
  B. Classification of queuing problems
    1. Deterministic and probabilistic
    2. Static and dynamic
    3. Network characteristics
      a. With respect to queuing stations
        (1) Single station
        (2) Parallel stations
        (3) Series of stations
      b. With respect to channels
        (1) Single channels
        (2) Alternative channels
        (3) Fusion of channels
    4. Typical assumptions for static deterministic models
      a. Input-output mechanism
      b. Measures of effectiveness

C. Monte Carlo approach to queuing problems
   1. Historical development
   2. Table of random numbers
   3. Methods of generating random numbers
   4. Random sampling techniques
   5. General theory of the Monte Carlo technique

III. Techniques of Simulation
   A. Units of instruction
      1. Definitions
         a. Simulation
         b. Model
         c. Gaming
         d. Algorithm
         e. Heuristic
         f. Stochastic
      2. Concept of simulation validity
         a. Face validity
         b. Interim validity
         c. Experimental validity
      3. Examples of simulation
         a. Simulation and training
         b. Simulation and prediction
         c. Simulation and player-participation
   B. Laboratory
      Obtain a simulation program from the program library. Determine the program logic, degree of suboptimization, and offer a critique on its validity. Programs are available for many simulation tasks including farm management and systems simulation. Selection should be determined by student interest.

IV. Game Theory
   A. Units of instruction
      1. Concepts and terminology
         a. Players in n-person games
         b. Strategies
         c. Payoffs
      2. Selection of management game for case study
         a. Rules of play
         b. Payoffs
         c. Analysis of program construction
   B. Laboratory
      Obtain a gaming program from the program library. Analyze and comment on game logic and offer a critique on its validity. Kinds of games that are available include: (1) Production Manpower Game, (2) Executive Game, (3) Market Management Game, and (4) Dairy Management and Business Management. Selection of program should be based on student interest.

V. Applications of Operations Research (units of instruction)
   A. Chemical and pharmaceutical industries
      1. Production scheduling
      2. Process optimization
      3. Inventory control
      4. Distribution
   B. Government systems planning
      1. Studies of particular investment projects
      2. Studies of a complete economic sector
      3. National, regional, and urban planning
   C. Transportation
      1. Cost characteristics
      2. Potential capacity
   D. Steel industry
      1. Planning of plant development
      2. Production planning
      3. Sales planning
      4. Planning of purchasing
      5. Planning for research and development
      6. Production control
      7. Process control
      8. Quality control
      9. Management control systems
   E. Mining industry
      1. Problems of prospecting
      2. Evaluation of deposits
      3. Decision to exploit a deposit
      4. Technical problems in exploitation
   F. Community services
      1. Study of hospital operations
      2. Analysis of congestion in outpatient clinics
      3. Linear programming for menu planning
      4. Community protection
   G. Textile industry
      1. Facilities planning
      2. Selection of product line
      3. Raw material purchase
      4. Color matching
   H. Agriculture
      1. Development of a climatic calendar
      2. Application of linear programming
   I. Defense program
      1. Analysis of military missions

2. Vehicle optimization
3. Management studies

Texts and References

ACKOFF. *Progress in Operations Research—Volume I.*

ACKOFF and RIVETT. *A Manager's Guide to Operations Research.*

BUFFA. *Models for Production and Operations Management.*

BURGER. *Introduction to the Theory of Games.*

CABELL and PHILLIPS. *Problems in Basic Operations Research for Management.*

CLOUGH. *Concepts in Management Science.*

DRESHER. *Games of Strategy: Theory and Applications.*

EDDISON and others. *Operational Research in Management.*

HANSSMANN. *Operations Research in Production and Inventory Control.*

HERTZ and EDDISON. *Progress in Operations Research—Volume II.*

KAUFMANN. *Methods and Models of Operations Research.*

KOENIGSBERG and BUCHAN. *Scientific Inventory Management.*

MILLER and STARR. *Executive Decisions and Operations Research.*

OPTNER. *Systems Analysis for Business and Industrial Problem Solving.*

SAATY. *Elements of Queuing Theory.*

SHUBIK. *Game Theory and Related Approaches to Social Behavior: Selections.*

TEICHROEW. *An Introduction to Management Science: Deterministic Models.*

VEINOTT. *Mathematical Studies in Management Science.*

WAGNER. *Statistical Management of Inventory Systems.*

FIELD PROJECT

Hours Per Week

Class, 2; laboratory, 6

Description

In this course, the student selects and solves a scientific problem which requires him to draw upon all his previous courses of study in order to arrive at a satisfactory project completion. The course is highly personalized in the sense of individual student activity and interest. Projects are selected and assigned on the basis of interest expressed by the student and the instructor's evaluation of the student's prior program performance. Emphasis is directed toward solving meaningful scientific problems or making applications which require command of the total system concept.

Major Divisions

	Hours Class	Hours Laboratory
I. Problem Selection and Analysis	12	10
II. Facility Orientation	4	10
III. Solution Procedure	10	40
IV. Student Report	6	36
Total	32	96

I. Problem Selection and Analysis

The student will be introduced to a specific problem which results from a conference period between a school official, the student, and a person or persons representing the problem source. This initial meeting should result in a complete problem definition and the expression of desired objectives. Care should be exercised to assure that the selected problem is realistic in light of available time and student's capability. It is important at this initial stage that agreement in course objectives be obtained from all participants involved in the problem. This will require a complete problem analysis to assure that sufficient data are available to allow adequate solution.

II. Facility Orientation

It is quite proper to expect that many students will perform in an industrial environment which is quite different from that experienced in previous laboratory exercises. It will be necessary, in these cases, to present an orientation phase to acquaint the student with established company policy relative to programming procedures and personnel. Insofar as is practical, the student should be expected to perform within the operating limitation established for the company employees. It is also to be expected that the degree of student responsibility for solution of the selected problem will be variable and depend largely upon the nature of the problem.

III. Solution Procedure

It is recognized that the diverse nature of problems which may be selected creates the need for the application of unique techniques. Yet, it is important to identify the common elements which are considered antecedent to effective performance. The evaluation of the attainment of common elements will afford an instrument for determination of the student's growth in the acquisition of knowledge and skill. Close cooperation between the instructor, problem source, and student during the process of problem solution is a requirement for the assurance of an effective learning process and must be maintained *on the initiative of school officials.*

After the problem has been selected, it is suggested that student, instructor, and a person representing the problem source hold a conference to determine the strategy for solution. Normally, such strategy will include the following steps: problem identification, identification of related variables, quantification of data, recognition of limitations, development of flow charts, coding in an acceptable language, test run on computer system, and the final run on a computer system using the data originating from the problem source.

The sources of problems are many and varied. Within the school system itself, problems may be accepted which are related to student selection procedures and their validity, student scheduling, inventory problems, linear programming problems, and problems related to Critical Path Methods and PERT. Hospitals and other educational institutions are also rich sources for meaningful problems. The instructor should exercise all measures necessary to assure that a meaningful and worthwhile project has been accepted by the student.

IV. Student Report

The student should be expected to prepare a formal report based on the experience obtained in pursuit of the problem solution.

It is conceivable that even with the most careful planning that the accepted problem will "grow" to unwieldy proportions in view of the time allotment. For this reason, primary consideration should be directed toward the elements of style, design, procedure, and an understanding of the relationships which exist between "poor" and "ideal" documentation. (See appendix B.)

Texts and References

Specific texts and references will consist of all texts previously used in the curriculum. In addition, considerable use will be made of manufacturers' literature written for specific "hardware" and/or applications.

Mathematics Courses

TECHNICAL MATHEMATICS I

Hours Per Week

Class, 5

Description

This course is the first of two mathematics courses designed specifically for scientific data processing. Its organization and content require the satisfactory completion of a minimum of one semester of high school algebra. The sequence of presentation of mathematical subjects and concepts is traditional, and adherence to its order is strongly recommended.

Major Divisions

		Class Hours
I.	Review of Elementary Algebra	6
II.	Linear Equations	5
III.	Factoring	9
IV.	Fractions	9
V.	Exponents and Radicals	9
VI.	Quadratic Equations	8
VII.	Logarithms	10
VIII.	Determinants	7
IX.	Introduction to Matrices	7
X.	Trigonometry	10
	Total	80

I. Review of Elementary Algebra (units of instruction)
- A. Introduction
  1. Literal number
  2. General number
- B. Fundamental operations
  1. Addition
  2. Subtraction
  3. Multiplication
  4. Division
- C. Fundamental assumptions
  1. Commutative law for addition
  2. Associative law for addition
  3. Commutative law for multiplication
  4. Associative law for multiplication
  5. Distributive law for multiplication
- D. Signed numbers
- E. Operations with signed numbers
- F. Algebraic expressions
  1. Term
  2. Factor
  3. Coefficient
- G. Exponents
  1. Power
  2. Base
- H. Term operations
  1. Addition and subtraction
  2. Multiplication
  3. Power of terms
  4. Division of terms
- I. Symbols of grouping
  1. Parentheses
  2. Brackets
- J. Polynomials
  1. Addition and subtraction of polynomials
  2. Multiplication of polynomials
  3. Division of polynomials
- K. Functions
  1. Independent variable
  2. Dependent variable
  3. Examples of functions involving both single independent variables and multi-independent variables.
- L. Rectangular coordinates
  1. Abscissa
  2. Ordinate
- M. Graphs

II. Linear Equations (units of instruction)
- A. Linear equations in one unknown
- B. Worded problems
- C. Linear equations in two unknowns
  1. Simultaneous solution
  2. Solution by graph
- D. Linear equations in three or more unknowns

III. Factoring (units of instruction)
- A. Elementary factor types
  1. Common factor
  2. Difference of two squares
  3. Trinomial perfect squares
  4. Sum of two cubes
  5. Difference of two cubes
- B. Equation solution by factoring

IV. Fractions (units of instruction)
   A. Introduction
      1. Numerator
      2. Denominator
      3. Signs
   B. Operations with fractions
      1. Addition and subtraction
      2. Multiplication and division
      3. Powers
   C. Complex fractions
   D. Extraneous roots
   E. Equations involving fractions

V. Exponents and Radicals (units of instruction)
   A. Laws of exponents
   B. Roots
   C. Fractional exponents
   D. Negative exponents
   E. Rationalizing the denominator
   F. Operations with radicals
      1. Addition and subtraction
      2. Division
      3. Multiplication
   G. Imaginary and complex numbers
   H. Operations with complex numbers

VI. Quadratic Equations (units of instruction)
   A. Methods of solution
      1. Factoring
      2. Completing the square
      3. Graphical method
      4. Quadratic formula
   B. Character of the roots
      1. Relationship to the discriminant
      2. Real roots
      3. Imaginary roots
   C. Graphic representation of a quadratic function
      1. Maximum value of the function
      2. Minimum value of the function
   D. A system of one linear and one quadratic
      1. Solution by substitution
      2. Graphical representation of solution
      3. Word problems

VII. Logarithms (units of instruction)
   A. Introduction and definitions
      1. Logarithm
      2. Base
      3. Mantissa
      4. Characteristic
      5. Antilogarithm
   B. The logarithm table
   C. Process of interpolation
   D. Laws of logarithms
      1. Multiplication
      2. Division
      3. Exponentiation
   E. Operations with logarithms
      1. Exponential equations
      2. Linear equations
   F. Bases other than 10
      1. Natural logarithms
      2. Calculations involving logarithms, base e

VIII. Determinants (units of instruction)
   A. Second- and third-order determinants
   B. Characteristics of determinants
      1. Interchangeability of rows and columns
      2. Influence of row-column change and determinant sign
      3. Case of two columns or rows being identical
      4. Results of scalar multiplication
      5. Result of a zero row or column
   C. Expansion of a determinant by minors
   D. Application of determinants to the solution of linear equations

IX. Introduction to Matrices (units of instruction)
   A. Simple matrix concepts
      1. Definition of terms
      2. Types of matrices
      3. Transpose of a matrix
   B. Simple matrix computations
      1. Addition and subtraction of matrices
      2. Vector multiplication
      3. Matrix multiplication
      4. Matrix identity and inverse
      5. Eigenvalues of matrices
   C. Systems of linear equations
      1. Method of writing linear systems as a matrix equation
      2. Find and use an inverse for a coefficient matrix to find the solution set for a system of linear equations of degree n.

X. Trigonometry (units of instruction)
   A. Radian measure
   B. Functions of angles
   C. Graphical representation of trigonometric functions
   D. Application of trigonometry
      1. Solution of right triangles

2. Laws of sines
3. Laws of cosines

E. Trigonometric identities

F. Inverse trigonometric functions
1. Arc sine
2. Arc tangent
3. Principal values

Texts and References

DUBISCH and HOWES. *Intermediate Algebra.*
FISHER and ZIEBUR. *Integrated Algebra and Trigonometry.*
JUSZLI and RODGERS. *Elementary Technical Mathematics.*
RICE and KNIGHT. *Technical Mathematics.*
SLADE and MARGOLIS. *Mathematics for Technical and Vocational Schools.*
TUITES. *Basic Mathematics for Technical Courses.*

TECHNICAL MATHEMATICS II

Hours Per Week

Class, 4; laboratory, 3

Description

This course presents the fundamental concepts of calculus and offers an introduction to general methods of solution. It follows and builds upon the subject matter learned in *Technical Mathematics I*. Emphasis is directed toward the practicality of calculus solutions to defined problems and the relationship of calculus to computer procedures. Laboratory time is directed toward the processing of computer programs designed to support the theoretical concepts presented in class.

Major Divisions

	Hours: *Class*	Hours: *Laboratory*
I. Solution by Graphic Methods	12	3
II. Differentiation	16	3
III. Integration	16	3
IV. Centroids and Moments	20	3
V. Computer Applications	0	36
Total	64	48

I. Solution by Graphical Methods
- A. Units of instruction
  1. Functions
     - a. Dependent variable
     - b. Independent variable
  2. Rates of change
     - a. Slope formula
     - b. Slope relationship to dependent and independent variable
  3. Area under a straight line
     - a. Area either a triangle or trapezoid
     - b. Derivation of formula
  4. Calculations from graphs
     - a. Work from a force-distance graph
     - b. Distance from a speed-time graph
  5. Slope of nonlinear functions
     - a. Change characteristic
     - b. Tangent concept
  6. Concepts of average and instantaneous slopes
     - a. Definition of average slope
     - b. Definition of instantaneous slope
  7. The derivative
     - a. Definition of derivative
     - b. Approximate increments
     - c. Differential notation
     - d. Maxima and minima
     - e. Points of inflection
     - f. Notation for derivatives
- B. Laboratory
  1. Given $y = -x^2 + 5x + 6$.
     Find y at x equal to –1, 2, 5, 6.
     Connect these points by a series of straight lines, thus getting a series of linear approximations to the curve $y = -x^2 + 5x + 6$. Compute the area under the straight line approximations and add these three areas together to find an approximation to the total area under the curve between $x = -1$ and $x = 6$.
  2. Given $y = x^2 + 2$. Write a FORTRAN program to compute and print out successive approximations for the derivative of y at $x = 2$ using increments
     - a) $\triangle x = 1., .5, .1, 105, .01, .005, .001$
     - b) $\triangle x = -1, -.5, -.1, -.05, -.01, -.005, -.001$
     - c) $\triangle x = 1., -.5, .1, -.05, .01, -.005, .001$

     Analyze and compare answers a, b, c.
  3. Given $y = 1/3\ (x + 7)$ on interval [2, 5] and $y = x + 1$ on interval [–1, 2]. Write a FORTRAN program to compute and print out successive approximations for the derivative at $x = 2$ using increments
     - a) $\triangle x = 1., .5, .1, .05, .01, .005, .001$
     - b) $\triangle x = -1., -.5, -.1, -.05, -.01, -.005, -.001$
     - c) $\triangle x = 1., -.5, .1, -.05, .01, -.005, .001$

     Analyze and compare results a, b, c.

II. Differentiation
- A. Units of instruction
  1. Variables, functions, and limits
     - a. Limit concept
     - b. Limiting value of a function
     - c. Continuity
     - d. Infinity
  2. Increment of a function

3. Notation of increment
4. Delta method of finding the derivative
5. General rules for differentiation
   a. Power function
   b. The derivative of an added constant
   c. Multiplication
   d. The derivative of a sum or difference
6. Common derivation formulas
   a. $y = u^n$
   b. Derivative of sin ϕ and cos ϕ
   c. Differentiating the function $y = e^x$
   d. Derivative of e^u where u is a function of x
   e. Derivative of $1n\ x$
   f. Derivative of $1n\ u$ where u is a function of x
   g. Derivative of tan u
7. Equations of motion

B. Laboratory

Write a FORTRAN program to compute and print out successive approximations to the derivative at a given point a, using successively smaller increments for the independent variables.

1. $y = \sin\ (x) \qquad a = \frac{\pi}{6}$(radians)
   a) $\triangle x = .1, .05, .01, .005, .001$
   b) $\triangle x = -.1, -.05, -.01, -.005, -.001$
   c) $\triangle x = .1, -.05, .01, -.005, .001$
2. $y = e^x$ at $a = 1$
   a) $\triangle x = .1, .05, .01, .005, .001$
   b) $\triangle x = -.1, -.05, -.01, -.005, -.001$
   c) $\triangle x = .1, -.05, .01, -.005, .001$

   Compare results for Nos. 1 and 2 with analytical results obtained through classroom methods.

III. Integration

A. Units of instruction

1. Introduction to integration
   a. Notation of integration
   b. The indefinite integral
2. The rule for $\int kx^n\ dx$
3. The coefficient constant in integration
4. Evaluating the constant of integration
5. Integration equations of uniform acceleration
6. Graphical representation of areas under a curve
   a. The definite integral as the limit of a sum
   b. Average ordinates
7. Formula of integration
   a. Integral of $ku^n\ du$
   b. Integral of sin $u\ du$
   c. Integral of cos $u\ du$
   d. Integral of $ke^u\ du$
8. Area determination by integration
9. Volume determination by integration
10. Special methods of integration
    a. Tables of integrals
    b. Algebraic substitution
    c. Trigonometric substitution
    d. Integration by parts
    e. Partial fractions
    f. Simpson's rule
11. Application of integration to problem solution

B. Laboratory

1. Write a FORTRAN program to evaluate $\int_1^2 \ (x^2 + x + 1)\ dx$

   using Simpson's rule using $n = 5$.
2. Write a FORTRAN program to evaluate $^1\int_0 \ \frac{\pi}{2}\cos\ (x)\ dx$

   using Trapezoidal rule with $n = 10$.
3. Write a FORTRAN program to evaluate $\int_0 \frac{\pi}{2} \cos(x)dx$

   by a sum of areas of rectangles using $n = 10$. Compare No.'s 2. and 3. with analytical results for closed form solution of $\int_0 \frac{\pi}{2} \cos(x)\,dx$.

IV. Centroids and Moments

A. Units of instruction

1. Moments of force
2. The centroid of a rectangular volume
3. The first moment
   a. Definition and notation
   b. The first moment of volumes, areas, and lines
   c. Addition of first moments
4. Centroids
   a. Definition and notation
   b. Centroid of area by integration
   c. Relation to axis of symmetry
5. Centroid of volumes
   a. Volumes of revolution
   b. Other volumes
6. Moment of inertia

B. Laboratory

Write a FORTRAN program to compute the moment about the x axis, $\mathbf{M}_x$; the moment about the y axis, M_y; the area A; and hence the centroid values

$\bar{x} = \frac{M_x}{A}$; $\bar{y} = \frac{M_y}{A}$; for the area bounded by $y = x^3$, $y = 8$, $x = 0$.

V. Computer Applications

A. Units of instruction (program development)

1. Problem identification
2. Flow chart
3. Code
4. Compile
5. Execute
6. Test
7. Documentation of problem and its solution

B. Laboratory

1. Write and execute a FORTRAN program that evaluates and prints the value of $I = \int_a^b (a_0 + a_1x + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5 + a_6x^6)\, dx$. Use Simpson's rule with n intervals. Design the program such that a_0, a_1, a_2, a_3, a_4, a_5, and a_6, are read from one card and values for a, b, and n from another card.
2. Develop suitable data and execute sufficient package programs for integration and differentiation necessary to illustrate computer usage in problem solution.
3. Find the volume under the function $z = x^2 + y^2 + 2$ over the area bounded by the lines $x_1 = 2$, $x_2 = 4$, $y_1 = 1$, $y_2 = 5$. Subdivide the area described by the above lines into rectangles and evaluate the function over the midpoint of each rectangle. Using the z just obtained as a height, the width of the rectangle Δx, the length of the rectangle Δy, find the volume of each rectangular solid whose dimensions are Δx, Δy, z. Read in n for the number of subintervals for the x axis, and m for the number of subintervals for the y axis.

   Then $\Delta x = \frac{x_2 - x_1}{n} = \frac{4-2}{n} = \frac{2}{n}$;

   $\Delta y = \frac{y_2 - y_1}{m} = \frac{5-1}{m} = \frac{4}{m}$.

   Total the volumes of all such rectangular solids for a numerical approximation to the problem stated in the first line.

Texts and References

ADAMS. *Applied Calculus.*

ELLIOTT and others. *Mathematics: Advanced Course.*

FORD and FORD. *Calculus.*

GOLDE. *FORTRAN II and IV for Engineers and Scientists.*

MCCRACKEN and DORN. *Numerical Methods and Fortran Programming.*

RALSTON and WILF. *Mathematical Methods for Digital Computers.*

WASHINGTON. *Basic Technical Mathematics with Calculus.*

STATISTICS

Hours Per Week

Class, 5

Description

This course is designed to present the fundamental concepts of statistics to the student in a manner that will teach the relationship between statistical procedures and computer solutions. The order and emphasis of topics are closely correlated with the content of the course entitled *Statistical Programming and the Life Sciences*, which is taught concurrently, in order that the student may recognize the immediate application of the concepts he is learning.

Major Divisions

		Class Hours
I.	Introduction to Statistical Inference	6
II.	Elementary Number Usage Techniques	6
III.	Probability	8
IV.	Techniques of Sampling	10
V.	Tests of Hypotheses	14
VI.	Linear Regression and Correlation	10
VII.	Other Measures of Relationship	8
VIII.	Statistical Quality Control in Production and Management	5
IX.	Statistical Analysis of Time Series Data	4
X.	Index Numbers	4
XI.	Forecasting and Market Research	5
	Total	80

I. Introduction to Statistical Inference (units of instruction)
   A. Definition and purpose of statistics
   B. Sources of data
   C. Samples and population
   D. Inferences made from samples
   E. Scientific method and applied statistics
   F. A brief history of statistics

II. Elementary Number Usage Techniques (units of instruction)
   A. Organizing univariate data
   B. Measures of central tendency
      1. The arithmetic mean
      2. The median
      3. The mode
      4. Graphical representation and applications
   C. Measures of variability
      1. The range
      2. The standard deviation
      3. The standard deviation of means
   D. Frequency table

III. Probability (units of instruction)
   A. Definition of probability
   B. Discrete and continuous probability distributions
   C. Mutually exclusive classes
   D. Exhaustive classes
   E. Laws for the combination of probabilities
      1. Addition laws
      2. Multiplication laws
   F. Normal distribution
   G. The distribution of means
   H. The t-distribution
   I. Probability tables

IV. Techniques of Sampling (units of instruction)
   A. Sampling distribution from a finite population
      1. Without replacement
      2. With replacement
   B. Sampling from an infinite population
   C. Random sampling
   D. Use of table of random sampling numbers
   E. The central limit theorem
   F. Sampling from a normal distribution
      1. Assumptions made about the sample
      2. Distribution of sample variance
      3. The standard deviation of the mean

V. Tests of Hypotheses (units of instruction)
   A. Null and alternate hypotheses
   B. Type I error
   C. Type II error
   D. Significance tests
   E. Tests concerning means
   F. Test of "goodness of fit"

VI. Linear Regression and Correlation (units of instruction)
   A. The scatter diagram
   B. The regression line
   C. The coefficient of correlation

1. Determination of reliability
2. Determination of validity
3. Formulation of predictions

VII. Other Measures of Relationship (units of instruction)
A. Analysis of variance
1. One-way classification
2. Two-way classification
3. Factorial designs
4. Fixed model
5. Random model
6. Mixed model
B. Biserial correlation
C. Point biserial correlation
D. Factor analysis
1. Correlation matrix and factor loadings
2. Interpretation of residual matrix
3. Communality
4. Methods of factor analysis
5. Applications

VIII. Statistical Quality Control in Production and Management (units of instruction)
A. Statistical surveillance of repetitive processes
B. Manufacturing process control
C. Control charts for variables
D. Control charts for attributes
E. Sampling plans
F. Risks in quality control

IX. Statistical Analysis of Time Series Data (units of instruction)
A. Behavior of time series
1. Secular trend
2. Seasonal variation
3. Cyclical variation
4. Irregular variation
B. Graphical presentation of time series
C. Moving averages
D. Time series analysis and forecasting

X. Index Numbers (units of instruction)
A. Statistical methods in index number construction
1. Unweighted index numbers
2. Weighted index numbers
B. Chain index numbers
C. Shifting the base
D. Consumer price index
E. Industrial production index
F. Current problems

XI. Forecasting and Market Research (units of instruction)
A. Forecasting techniques
B. Input-output analysis
C. Market distribution research
D. Survey of consumer buying plans

Texts and References

BLALOCK. *Social Statistics.*
BORKO. *Computer Applications in the Behavioral Sciences.*
BROWN. *Smoothing, Forecasting, and Prediction.*
FREUND. *Mathematical Statistics.*
FREUND and WILLIAMS. *Modern Business Statistics.*
GUENTHER. *Analysis of Variance.*
HAYES. *Statistics for Psychologists.*
WEISS. *Statistical Decision Theory.*
WINE. *Statistics for Scientists and Engineers.*

SCIENTIFIC DATA PROCESSING TECHNOLOGY SEMINAR

Hours Per Week

Class, 1

Description

This course is designed first to orient the beginning student in a post high school educational program at the beginning of the curriculum. A brief introduction to the new type of learning situation is followed by an explanation of the objectives of the course and how they will be accomplished in the seminar. The remainder of the course is devoted to giving the student occupational and professional orientation by means of student panel reports and class discussion on pertinent topics. These topics should be assigned to panel groups at the first or second meeting of the class, with emphasis on the principle that the student groups are responsible for preparing a report and leading class discussion on the topics assigned. Students should be given topics of their choice within the scope of the course, as much as possible.

By preparing themselves and leading the class discussion under the instructor's guidance, the students become informed by active involvement in the development of the topics studied. The student panels can be expanded by including guest panelists from industry or the professions. The class should be encouraged to question the panel members and even to take issue if controversial subject matter is under discussion.

The exploration of occupational opportunities and the variety of experiences required of industry will do much to motivate the students' curiosity and interest. Industrial participation, as panel members, will offer to industry an opportunity to become acquainted with the school and its objectives.

Panel reports should be written and sources documented prior to oral presentation to the class for discussion. A notebook should be required, made up of the student's part of the panel report for which he is responsible and complete class notes.

Major Divisions

	Class Hours
I. The Student and the School	1
II. The Library and Its Use	1
III. The Scientific Method—Its Effect on Technician's Attitude	1
IV. Types of Data Processing Education	3
V. Technical Personnel	2
VI. Opportunities in the Scientific Data Processing Field	1
VII. Types of Jobs in Scientific Data Processing	1
VIII. Technical Subjects in Relation to General Education	2
IX. Future Trends in Data Processing Techniques	2
X. Summary Discussion of Data Processing Topics	2
Total	16

I. The Student and the School
  A. Physical facilities, regulations, academic requirements
  B. How to plan use of time
    1. For study
    2. For student activities
  C. Seminar objectives and plan of operation
  D. Notebook—required content
  E. Assignment of topics and schedule for panel reports

II. The Library and Its Use
  A. Why technicians need a library
  B. Library organization and facilities
  C. Services of the library staff
  D. How to use the library

III. The Scientific Method—Its Effect on Technician's Attitude
  A. Elements of the scientific method
  B. Scientific observation and intellectual honesty
  C. Data processing laboratory work record books
    1. Need for accuracy and completeness
    2. Legal record for process or product patents

D. Need for ethical standards in light of responsibility for confidential and important work

IV. Types of Data Processing Education
- A. Business data processing technology
- B. Scientific data processing technology
- C. Four-year college programs in computer science
- D. Programs in information science
- E. Comparisons of objectives, costs, time, effort, starting salary, and promotional opportunities

V. Technical Personnel
- A. Occupational levels and qualifications
- B. The engineering team—scientists or engineers, technicians, skilled craftsmen (relationship of the engineer, scientist, and skilled craftsmen to the technician)
- C. The data processing technician
  1. Need for constant study to maintain technical "up-to-dateness"
  2. Technical societies
  3. Formal supplementary study

VI. Opportunities in the Scientific Data Processing Field
- A. Size and growing importance of scientific data processing applications
- B. Expanding demand for qualified personnel (few programs, personnel shortage, and promotional opportunities)
- C. Trends in technician salaries

VII. Types of Jobs in Scientific Data Processing
- A. Production and quality control
- B. Numerical control
- C. Process control
- D. Critical path planning
- E. Simulation
- F. Statistical programming
- G. Application of linear programs
- H. Programming for engineering applications

VIII. Technical Subjects in Relation to General Education
- A. Communications Skills
- B. General and Industrial Economics
- C. Industrial Organizations and Institutions

IX. Future Trends in Data Processing Techniques
- A. Changes in hardware
- B. Software changes
- C. Requirements for personnel
- D. New applications

X. Summary Discussion of Data Processing Topics
- A. Review of topics
- B. Analysis of values

Texts and References

This course is an ideal approach to library assignments which require the students to search for pertinent information on the topics studied. Since this is a working seminar in which most of the classwork will be presentation of organized reports by small panels of students, it is suggested that the instructor, upon assignment of topics, advise the students to seek their own references for a written and documented report which should be a part of their panel's presentation. Therefore, no texts or references are listed.

TECHNICAL REPORTING

Hours Per Week

Class, 2

Description

This course, an extension of *Communication Skills,* aims to help the student achieve greater facility in the basic skills he has previously acquired. The student is introduced to the practical aspects of preparing reports and communicating within groups. The use of graphs, charts, sketches, diagrams, and drawings to present ideas and significant points is an important part of this course.

Emphasis should be upon techniques for collecting and presenting scientific data by means of informal and formal reports, and special types of technical papers. Forms and procedures for technical reports should be studied, and a pattern established for all forms to be submitted in this and other courses. Much of the subject matter for this course may be necessary reports written for technical courses. The subject matter taught in this course should be coordinated with that of the course studied concurrently, *Graphical Representation.*

Major Divisions

	Class Hours
I. Reporting	3
II. Writing Technical Reports	12
III. Illustrating Technical Reports	4
IV. The Research Paper	3
V. Oral Reporting	4
VI. Group Communication and Participation	6
Total	32

I. Reporting (units of instruction)
  A. Nature and types of reports
  B. Objective reporting
  C. The problem concept
  D. The scientific method
    1. Meaning of the method
    2. Characteristics of the scientific method
    3. Essentials of scientific style
    4. Importance of accuracy and intellectual honesty in observation and recording
    5. Legal importance of recorded data and log books.
  E. The techniques of exposition
    1. Definitions
    2. Progression
    3. Elements of style
    4. Analysis of examples
    5. Methods of slanting a report
  F. Critical evaluation of a report

II. Writing Technical Reports (units of instruction)
  A. Characteristics of technical reports
  B. Report functions
  C. Informal reports (short-form reports)
    1. Memorandum reports
    2. Business letter reports
    3. Progress reports
    4. Outline reports
  D. The formal report
    1. Arrangement
      a. Cover and title page
      b. Table of contents
      c. Summary of abstracts
      d. Body of the report
      e. Bibliography and appendix
      f. Graphs, drawings, or other illustrations
    2. Preparation
      a. Collecting, selecting, and arranging material
      b. Writing and revising the report
  E. Special types of papers
    1. The abstract
    2. Process explanations
    3. The case history
    4. The book review

III. Illustrating Technical Reports (units of instruction)
  A. Illustrations as aids to brevity and clarity
  B. Use of technical sketching and drawings
  C. Use of pictorial drawings and sketches
  D. Use of diagrammatic representation
    1. Electrical diagrams and symbols
    2. Process flow diagrams
    3. Instrumentation diagrams
    4. Bar charts, pie diagrams, and similar presentation of data
  E. Graphical presentation of data
    1. Graphs—types of graph paper
    2. Choice of scale for graphs

3. Points and lines and use of data from graphs
F. Use of photographs
G. Selection of appropriate illustrations
1. Availability
2. Cost of preparation
3. Maximum brevity and clarity of presentation

IV. The Research Paper (units of instruction)
A. Subject and purpose
B. Source materials: bibliographical tools, periodical indexes, the library
C. Organizing the paper
1. A working bibliography
2. Notes and the outline
3. The rough draft
4. Quoting and footnoting
5. The final paper
D. Oral and written presentation of the paper

V. Oral Reporting (units of instruction)
A. Organization of material for effective presentation
B. Formal and informal reports
C. The use of notes
D. The use of slides, exhibits
E. The proper use of the voice
F. Elimination of objectionable mannerisms
G. Introductions

VI. Group Communication and Participation (units of instruction)
A. The problem-solving approach
1. Stating and analyzing the problem
2. Proposing solutions
3. Selecting and implementing a solution
B. Participating in group communication
1. The chairman—duties and qualifications
2. Rules of order
3. The panel discussion and symposium
4. Group investigation

Texts and References

BAIRD and KNOWER. *Essentials of General Speech.*
CROUCH and ZETLER. *A Guide to Technical Writing.*
DEAN and BRYSON. *Effective Communication.*
HARWELL. *Technical Communication.*
HAYS. *Principles of Technical Writing.*
MARDER. *The Craft of Technical Writing.*
PERRIN and SMITH. *Handbook of Current English.*
RHODES. *Technical Report Writing.*
SCHUTTE and STEINBERG. *Communications in Business and Industry.*
SHERMAN. *Modern Technical Writing.*
STEWART and others. *Business English and Communications.*
ZETLER and CROUCH. *Successful Communications in Science and Industry: Writing, Reading, and Speaking.*

GRAPHICAL REPRESENTATION

Hours Per Week

Laboratory, 4

Description

This is a beginning course for students who have had little or no previous experience in drafting. The course is designed to develop an understanding of drafting rather than skill as a draftsman. The principal objectives are to develop: an elementary but basic understanding of orthographic projection; some skill in orthographic, isometric, and oblique sketching and drawing; an elementary understanding of principles and some appropriate applications of descriptive geometry; some experience in using handbooks and other resource materials; and an elementary understanding of design principles and the use of simplified drafting practices in industry. Several specialized drafting areas are introduced that will be valuable to the scientific data processing technician in his interpretation of flow charts, process drawings, and the development of Critical Path Methods (CPM) from engineering drawings.

The drawing and illustrative skills acquired in this course should be employed extensively in the concurrently studied *Technical Reporting* course and should be reflected in the reports written for technical courses throughout the remainder of the curriculum. The use of drawing and sketching aids and techniques should take precedence over precision and quality of lines and lettering in the teaching of this course. Neatness must be emphasized, but the objective of the course is to develop illustrative and graphic communication skills rather than technical drafting proficiency.

It is expected that this course will be taught in a drafting room equipped with a blackboard, where the instructor will devote a part of each period to demonstrating various techniques for drawing, free-hand sketching, graphing, charting, and diagramming; and where the rest of the laboratory period will be used to practice the demonstrated skills and techniques.

Major Divisions

	Laboratory Hours
I. Fundamentals	3
II. Technical Sketching, Orthographic Projection	16
III. Isometric and Oblique Pictorial Sketching	7
IV. Dimensioning	10
V. Sections	8
VI. Auxiliary Views	10
VII. Architectural Drawing Principles	10
Total	64

I. Fundamentals
- A. Units of instruction
  1. Function of drafting in design and production
  2. Drafting instruments, materials, and equipment
     - a. Care and use
     - b. Current drafting practices in industry
  3. Geometrical construction (accurate notes required)
     - a. Geometric forms and shapes
     - b. Geometry applied to drafting problems
     - c. Constructions involving straight lines, angles, circles, arcs, tangents, ellipses, parabolas, hyperbolas, helices, involutes, and cycloids
- B. Laboratory
  1. Draw with a pencil, on vellum or tracing paper, two or more mechanical parts of objects (single view) which provide an opportunity to use basic drawing instruments. Stress accuracy in full-scale measurement, make first applications of vertical gothic lettering, utilize basic geometrical constructions, and make typical sheet layouts.
  2. Produce first drawings as a device for critical analysis of line quality. Compare quality with that of good industrial prints. This practice is followed periodically throughout the course.

II. Technical Sketching, Orthographic Projection
- A. Units of instruction
  1. Sketching materials
  2. Sketching techniques
  3. Theory of third-angle orthographic projection

a. Definition
b. Planes of projection
(1) Frontal
(2) Horizontal
(3) Profile
c. Introduction of principles of descriptive geometry
(1) Locating points in space
(2) Locating lines in space
(3) Locating surfaces in space
d. Edges and surfaces
(1) Parallel
(2) Inclines
(3) Oblique
(4) Curved
(5) Truncated
e. Fillets, rounds, and runouts

4. Multiview sketches: two-view, three-view.
a. View relationships
(1) Principles of projection
(2) Selection of views for best shape description
b. Steps in sketching
(1) Estimating size and proportion of objects
(2) Determination of appropriate scale for sketch
(3) Centering sketch on pad or sheet selected
(4) Blocking in shapes of views
(a) Construction lines
(b) Solid lines
(c) Center lines
(d) Hidden lines
(5) Projecting views
(a) Spaces between views
(b) Transfer of measurements
(6) Order of sketching
(7) Quality of finished sketch
c. Techniques for sketching circles, ellipses, and other shapes
d. Analysis of engineering drawings and sketches from industry
e. Alphabet of lines
f. Explanation of first-angle projection

B. Laboratory
1. Examine several three-view drawings and sketch in any missing lines.
2. In several problems where two views of an object are given, sketch a third view.
3. Sketch three-view drawings from pictorial representations of selected machine parts or objects, using cross-section paper.
4. Sketch three-view drawings from actual machine parts or objects, using sketch pad or tracing paper.
5. Using drafting instruments and equipment, make three-view drawings of selected machine parts involving the principles and techniques covered in the units of instruction. Make drawings on vellum or tracing paper.
6. Reproduce one or more of the mechanical drawings as a basis for discussion of line equality.

III. Isometric and Oblique Pictorial Sketching
A. Units of instruction
1. Isometric sketching
a. Materials
b. Principles
c. Techniques
2. Oblique sketching
a. Cavalier drawing principles
b. Cabinet drawing principles
c. Positioning of object
d. Steps in oblique drawing
e. Offset measurements
f. Ellipses
g. Arcs and curves
h. Angles
i. Sections
B. Laboratory
1. Using isometric paper, make several isometric sketches from three-view drawings provided by the instructor, incorporating the principles taught in Unit 1 of Division III.
2. Using cross-section paper, make several oblique drawings (sketches from drawings or objects provided by the instructor), incorporating the principles taught in Unit 2 of Division III.

IV. Dimensioning
A. Units of instruction
1. Theory of dimensions
a. True-position dimensions
b. Maximum material position
2. Technique of dimensioning
a. Lines
b. Arrowheads
c. Fractional and decimal dimensions

d. Leaders
e. Fillets and rounds
f. Finish marks
g. Notes
3. Selection of dimensions
4. Placement of dimensions
5. Examination, analysis, and interpretation of dimensioning practices on engineering drawings or prints from local industry
6. Rules for dimensioning isometric and oblique drawings

B. Laboratory
1. Using the drawings made in Division II and Division III projects, add the needed dimensions and notes.
2. Sketch or use drawing instruments in making a more complex three-view drawing from pictorial views or actual objects involving inclined surfaces, holes, rounds, and unusual shapes which require a variety of dimensioning techniques and considerable judgment in the selection and placement of dimensions and notes.

V. Sections
A. Units of instruction
1. Functions of sectional views
2. The cutting plane
a. Representation on working drawing
b. Location of cutting plane line
c. Direction of sight
3. Conventions
a. Cutting plane lines
b. Section lines (ASA)
c. Spokes, arms, ribs, and lugs in section
d. Breaks
4. Classification of sections
a. Full sections
b. Half sections
c. Broken-out sections
d. Revolved sections
e. Aligned sections
5. Dimensioning

B. Laboratory
Sketch or draw section views in drawings requiring several types of sections. The drawings may be provided by the instructor and completed by the student or drawn entirely by the student.

VI. Auxiliary Views
A. Units of instruction
1. Function of auxiliary views
2. Classification of surfaces
3. Primary auxiliary views—width, depth, height, auxiliaries
a. Direction or sight
b. Reference plane
c. Projection technique
d. Transfer of measurements
e. Auxiliary view from a principal view
f. Principal view from an auxiliary view
g. Dihedral angles
h. Plotted curves
4. Partial auxiliary views
5. Half auxiliary sections
6. Auxiliary sections
7. Secondary auxiliary views
8. Descriptive geometry applied to true measurements of lines, angles, and surfaces

B. Laboratory
1. From two- or three-view drawings supplied by the instructor, sketch auxiliary views in their proper relationship to the given views.
2. Using instruments, make a working drawing which includes both primary and secondary auxiliary views.

VII. Architectural Drawing Principles
A. Units of instruction
1. Classification
a. Floor plans
b. Elevations
c. Special layouts
d. Sections and details
2. Architectural drawing standards
a. Symbols
b. Units
c. Handbooks
3. Architectural drawing techniques

B. Laboratory
1. Analyze and interpret typical architects' blueprints, particularly those dealing with factory or commercial buildings.
2. Draw typical detail sections.

Texts and References

GIACHINO and BEUKEMA. *Drafting and Graphics.*
———. *Engineering-technical Drafting and Graphics.*
GIESECKE and others. *Technical Drawing.*
GRANT. *Engineering Drawing.*
HOELSCHER and SPRINGER. *Engineering Drawing and Geometry.*
SPENCER. *Basic Technical Drawing.*
ZOZZORA. *Engineering Drawing.*

BOOLEAN ALGEBRA

Hours Per Week

Class, 4

Description

This course is designed to teach the student a language and method by which objects can be classified as an aid to the solution of logical arguments. Emphasis is directed toward the use of Boolean algebra as a tool for use in the identification and solution of problems related to computer programming and verification of computer performance.

Major Divisions

	Class Hours
I. The Algebra of Classes	10
II. The Calculus of Propositions	12
III. Switches and Switching Algebra	12
IV. Methods of Simplification	15
V. Sentence Logic	10
VI. Geometrical Representation in N-space	5
Total	64

I. The Algebra of Classes (units of instruction)
   A. Basic definitions
   B. Fundamental laws
      1. Commutative
      2. Associative
      3. Distributive
      4. Indempotent
   C. Venn diagram representation of fundamental laws
   D. Events
      1. Simple
      2. Compound
      3. Mutually exclusive
   E. Simple probabilities

II. The Calculus of Propositions (units of instruction)
   A. Propositional connectives
      1. And
      2. Or
      3. If . . . then . . .
      4. If
      5. If and only if
      6. Not both . . . and . . .
      7. Neither . . . nor . . .
      8. But not
      9. Not . . . but . . .
      10. Either . . . or . . . but not both
   B. Truth tables
      1. Affirmation
      2. Denial
      3. Conjunction
      4. Alternation
      5. Implication
      6. Inclusion
      7. Equivalence
      8. Nonconjunction
      9. Nonalternation
      10. Nonimplication
      11. Noninclusion
      12. Nonequivalence
   C. Logic diagrams
      1. Stated propositions
      2. Construction of truth table
      3. Simplification by Veitch diagram
      4. Logic diagram representation of minterm and maxterm
      5. Interpretation of redundants

III. Switches and Switching Algebra (units of instruction)
   A. Switches and decision elements
   B. The postulates of switching algebra
   C. Theorems of switching algebra
   D. Switching function of two or more variables
      1. Venn diagram representation
      2. Veitch diagram representation
      3. Truth table formation

IV. Methods of Simplification (units of instruction)
   A. Simple tabular method
   B. Karnaugh map
      1. Advantages
      2. Methods of grouping
   C. Quine method
   D. Cranfield method
   E. Comparison of simplification methods

V. Sentence Logic (units of instruction)
   A. As a model of Boolean algebra
   B. Presentation of axioms
   C. Truth table completeness
   D. Axiom independence
   E. The deduction theorem

VI. Geometrical Representation in N-space (units of instruction)

A. Functions of one and two variables

B. Functions of three variables

C. Functions of N variables

D. Similar switching functions

Texts and References

ARNOLD. *Logic and Boolean Algebra.*

FLEGG. *Boolean Algebra and Its Application.*

HOERNES and HEILWEIL. *Introduction to Boolean Algebra and Logic Design.*

NASHELSKY. *Digital Computer Theory.*

RENWICK. *Digital Storage Systems.*

WARE. *Digital Computer Technology and Design.*

General Courses

COMMUNICATION SKILLS

Hours Per Week

Class, 3

Description

This course places emphasis throughout on exercises in writing, speaking, and listening. Analysis is made of each student's strengths and weaknesses. The pattern of instruction is directed principally toward helping students improve skills in areas where common weaknesses are found. The time allotments for the various elements within major divisions will depend upon the background of the class.

A brief consideration of technical reporting is included early in the course because of its importance in the orientation of the technician to his development and use of communication skills.

Major Divisions

	Class Hours
I. Communication and the Technical Specialist	2
II. Sentence Structure	6
III. Using Resource Materials	4
IV. Written Expression	20
V. Talking and Listening	10
VI. Improving Reading Efficiency	6
Total	48

I. Communication and the Technical Specialist (units of instruction)
- A. Why the technical specialist must be proficient in the art of communication
- B. Why written communication is an essential skill
  1. Statements and facts
  2. Expression of ideas
  3. Technical reporting
     a. Formal
     b. Informal
  4. Use of graphics to illustrate written communications
- C. Why oral communication is an essential skill
  1. Person-to-person expression of ideas and thoughts
  2. Verbal reporting
- D. Diagnostic tests

II. Sentence Structure (units of instruction)
- A. Review of basic parts of speech
- B. What makes complete sentences
- C. Use and placement of modifiers, phrases, and clauses
- D. Sentence conciseness
- E. Exercises in sentence structure

III. Using Resource Materials (units of instruction)
- A. Orientation in use of school library
  1. Location of reference materials, *Reader's Guide*, etc.
  2. Mechanics for effective use
  3. Dewey Decimal System
- B. Dictionaries
  1. Types of dictionaries
  2. How to use dictionaries
  3. Diacritical marks
- C. Other reference sources
  1. Technical manuals and pamphlets
  2. Bibliographies
  3. Periodicals
  4. *Industrial Arts Index*
- D. Exercises in use of resource materials
  1. *Reader's Guide*
  2. Atlases
  3. Encyclopedias
  4. Other

IV. Written Expression (emphasis on student exercise—units of instruction)
- A. Diagnostic test
- B. Paragraphs
  1. Development
  2. Topic sentence
  3. Coherence
- C. Types of expression
  1. Inductive and deductive reasoning
  2. Figures of speech
  3. Analogies
  4. Syllogisms
  5. Cause and effect
  6. Other

D. Written exercises in paragraph
E. Descriptive reporting
  1. Organization and planning
  2. Emphasis on sequence, continuity, and delimitation of pertinent data
F. Letter writing
  1. Business letters
  2. Personal letters
G. Mechanics
  1. Capitalization
  2. Punctuation—when to use
    a. Period, question mark, and exclamation point
    b. Comma
    c. Semicolon
    d. Colon
    e. Dash
    f. Parentheses
    g. Apostrophe
  3. Spelling
    a. Word division—syllabification
    b. Prefixes and suffixes
    c. Word analysis and meaning—context clues, phonetics, etc.
H. Exercises in mechanics of written expression

V. Talking and Listening (emphasis on student exercises—units of instruction)
  A. Diagnostic testing
  B. Organization of topics or subject
  C. Directness in speaking
  D. Gesticulation and use of objects to illustrate
  E. Conversation courtesies
  F. Listening faults
  G. Taking notes
  H. Understanding words through context clues
  I. Exercises in talking and listening

VI. Improving Reading Efficiency (units of instruction)
  A. Diagnostic test
  B. Reading habits
    1. Correct reading posture
    2. Light sources and intensity
    3. Developing proper eye span and movement
    4. Scanning
    5. Topic sentence reading
  C. Footnotes, index, bibliography, cross references, etc.
  D. Techniques of summary
    1. Outline
    2. Digest or brief
    3. Critique
  E. Exercise in reading improvement
    1. Reading for speed
    2. Reading for comprehension

Texts and References

BAIRD and KNOWER. *Essentials of General Speech.*
COWAN and MCPHERSON. *Plain English, Please.*
CROUCH and ZETLER. *A Guide to Technical Writing.*
DEAN and BRYSON. *Effective Communication.*
HARWELL. *Technical Communication.*
MARDER. *The Craft of Technical Writing.*
PERRIN and SMITH. *Handbook of Current English.*
RHODES. *Technical Report Writing.*
ROGET. *New Roget's Thesaurus of the English Language.*
SCHUTTE and STEINBERG. *Communications in Business and Industry.*
STEWART and others. *Business English and Communications.*
WITTY. *How to Become a Better Reader.*
ZETLER and CROUCH. *Successful Communications in Science and Industry.*

GENERAL AND INDUSTRIAL ECONOMICS

Hours Per Week

Class, 3

Description

This study of economics is designed to impart a basic understanding of the principles of economics and their implications, to develop the ability to follow an informed personal finance program, to aid in the development of intelligent consumption, and to provide an understanding of the underlying relationship of cost control to success in industrial enterprise. The programs and problems worked upon by a scientific data processing technician in research or production must ultimately be measured by a cost analysis. To be aware of this fact and to have a knowledge of elementary economics prepares the student for the cost-conscious environment of his future employment.

It is suggested that the instruction in this course be based on this pragmatic approach and that students be encouraged to study examples from industry as they learn about industrial cost analysis, competition, creation of demand, economic production, and the related aspects of applied economics.

Major Divisions

	Class Hours
I. Introduction	2
II. Economic Forces and Indicators	3
III. Natural Resources—The Basis of Production	3
IV. Capital and Labor	3
V. Business Enterprise	7
VI. Factors of Industrial Production Cost	8
VII. Price, Competition, and Monopoly	5
VIII. Distribution of Income	2
IX. Personal Income Management	2
X. Insurance, Personal Investments, and Social Security	3
XI. Money and Banking	3
XII. Government Expenditures—Federal and Local	3
XIII. Fluctuations in Production, Employment, and Income	2
XIV. The U.S. Economy in Perspective	2
Total	48

I. Introduction (units of instruction)
- A. Basic economic concepts
- B. Importance of economic influences

II. Economic Forces and Indicators (units of instruction)
- A. Economics defined
- B. Modern specialization
- C. Increasing production and consumption
- D. Measures of economic activity
  1. Gross national product
  2. National income
  3. Disposable personal income
  4. Industrial production
  5. Employment and unemployment

III. Natural Resources—The Basis of Production (units of instruction)
- A. Utilization and conservation of resources
- B. Renewable resources
- C. Nonrenewable resources
- D. Future sources

IV. Capital and Labor (units of instruction)
- A. Tools (capital)
  1. The importance of saving and investments
  2. The necessity for markets
- B. Large-scale enterprise
- C. Labor
  1. Population characteristics
  2. Vocational choice
  3. General education
  4. Special training
  5. Management's role in maintaining labor supply

V. Business Enterprise (units of instruction)
- A. Forms of business enterprise
  1. Individual proprietorship
  2. Partnership
  3. Corporation
- B. Types of corporate securities
  1. Common stocks
  2. Preferred stocks
  3. Bonds

C. Mechanics of financing business
D. Plant organization and management

VI. Factors of Industrial Production Cost (units of instruction)
A. Buildings and equipment
1. Initial cost and financing
2. Repair and maintenance costs
3. Depreciation and obsolescence costs
B. Materials
1. Initial cost and inventory value
2. Handling and storage costs
C. Processing and Production
1. Methods of cost analysis
2. Cost of labor
3. Cost of supervision and process control
4. Effect of losses in percentage of original product compared to finished product (yield) in chemical operations
D. Packaging and shipping
E. Overhead costs
F. Taxes
G. Cost of selling
H. Process analysis, a means to lower costs
I. Profitability and business survival

VII. Price, Competition, and Monopoly (units of instruction)
A. Function of prices
B. Price determination
1. Competitive cost of product
2. Demand
3. Supply
4. Interactions between supply and demand
C. Competition, benefits, and consequences
1. Monopoly and oligopoly
2. Forces that modify and reduce competition
3. History of Government regulation of competition
D. How competitive is our economy

VIII. Distribution of Income (units of instruction)
A. Increasing real incomes
B. Marginal productivity
C. Supply in relation to demand
D. Incomes resulting from production
1. Wages
2. Interest
3. Rents
4. Profits
E. Income distribution today

IX. Personal Income Management (units of instruction)
A. Consumption—the core of economics
B. Economizing defined
C. Personal and family budgeting
D. Analytical buying
1. Applying quality standards
2. Consumer's research and similiar aids
E. The use of credit
F. Housing—own or rent

X. Insurance, Personal Investments, and Social Security (units of instruction)
A. Insurance defined
B. Life insurance
1. Group, industrial, and ordinary life policies
2. Types of policies, their advantages and disadvantages
C. Casualty insurance
D. Investments
1. Savings accounts and Government bonds
2. Corporation bonds
3. Corporation stocks
4. Annuities
5. Pension plans
E. Social Security
1. Old-age and Survivor's Insurance
2. Unemployment Compensation
3. Medicare

XI. Money and Banking (units of instruction)
A. Functions of money
B. The Nation's money supply
C. Organization and operation of a bank
1. Sources of deposits
2. The reserve ratio
3. Expansion of bank deposits
4. Sources of reserves
D. The Federal Reserve System
1. Service functions
2. Control of money supply
E. Federal Deposit Insurance Corporation

XII. Government Expenditures—Federal and Local (units of instruction)
A. Economic effects
B. Functions of Government
C. Analysis of Government spending
D. Future outlook
E. Financing Government spending
1. Criteria of sound taxation
2. Tax revenues in the United States

3. Federal and State personal income taxes
4. Corporate income tax
5. Property tax
6. Commodity taxes

XIII. Fluctuations in Production, Employment, and Income (units of instruction)

A. Changes in aggregate spending
B. Output and employment
C. Other factors affecting economic fluctuations
1. Cost-price relationships
2. Fluctuations in demand for durable goods
3. Involuntary fluctuation of supply of commodities
4. Inflation and deflation of currency value
5. Economic effects of inventions and automation
D. Means of implementing fiscal policy
E. Government debt
1. Purposes of Government borrowing
2. How burdensome is debt
3. Problems of debt management

XIV. The U.S. Economy in Perspective (units of instruction)

A. Recent economic changes
1. Increased productivity and well-being
2. Effects of war and depression
3. New products and industries
4. Increase in governmental controls
B. Present economic problems of U.S. economy
1. The world market—a community of nations
2. International cooperation
3. Maintenance of prosperity and progress
4. Economic freedom and security
C. Communism
D. Fascism
E. Socialism
F. Problems common to all economic systems
G. Special economic problems of the United States

Texts and References

BLOOM and NORTHRUP. *Economics of Labor Relations.*
FAULKNER. *American Economic History.*
GITLOW. *Labor and Industrial Society.*
GORDON. *Economics for Consumers.*
GRANT and IRESON. *Principles of Engineering Economy.*
LYNN. *Basic Economic Principles.*
MARK and SLATER. *Economics in Action.*
SCHULTZ. *The Economic Value of Education.*
TAFT. *Economics and Problems of Labor.*
WALETT. *Economic History of the United States.*

INDUSTRIAL ORGANIZATIONS AND INSTITUTIONS

Hours Per Week

Class, 3

Description

A description and analysis of the roles of labor and management in the economy of the United States are presented in this course. Approximately half of the classroom time is devoted to labor-management relations, including the evolution and growth of the American labor movement and the development and structure of American business management. A study is made of the legal framework within which labor-management relations are conducted and the responsibilities of each in a democratic system of government. The second half of the course pertains to labor economics as applied to the forces affecting labor supply and demand, problems of unemployment, and wage determination on the national, industrial, and individual levels. Emphasis centers upon current aspects of industrial society with historical references intended only as background.

Major Divisions

	Class Hours
I. Labor in an Industrial World	9
II. Management in an Industrial Society	9
III. The Collective Bargaining Process	12
IV. Dynamics of the Labor Market	8
V. Wage Determination	7
VI. The Balance Sheet of Labor-management Relations	3
Total	48

I. Labor in an Industrial World (units of instruction)
  A. The nature and scope of the Industrial Revolution
    1. The factory system
    2. Occupational trends
    3. Mechanisms of adjustments
  B. The evolution of American labor unions
    1. Nature of early unions: basic system of craft unions
    2. Organizations by unions for solving problems
    3. Emergence of business unionism
    4. The changing role of government
  C. Structure and objectives of American unions
    1. Objectives in collective bargaining
    2. Political objectives and tactics
    3. Structure of craft and industrial unions
    4. Movement toward unity—the AFL-CIO merger

II. Management in an Industrial Society (units of instruction)
  A. The rise of big business
    1. Economic factors
    2. Dominance of the corporate firm
    3. Government, public policy, and big business
  B. The managerial revolution
    1. Changing patterns of ownership and management
    2. Scientific management
    3. Twentieth-century trends
  C. Structure and objectives of American industry
    1. Production for profit: an affluent society
    2. Structure of industry—organizational forms
    3. Ethics in a competitive economy

III. The Collective Bargaining Process (units of instruction)
  A. Legal framework
    1. Common-law provisions
    2. The growth of statute laws
      a. The antitrust laws; aid to emergence of collective bargaining
      b. The Adamson and La Follette Laws
      c. Norris-LaGuardia
      d. Wagner Act
      e. Taft-Hartley
      f. Landrum-Griffin and beyond
  B. Management and collective bargaining
  C. Bargaining procedures and tactics, including conciliation and mediation process
  D. Issues in collective bargaining
    1. Security issues
    2. Working conditions

3. Safety provisions and safety education
4. Money matters

E. Strikes and lockouts; tactics and prevention

F. Evaluation of collective bargaining

IV. Dynamics of the Labor Market (units of instruction)

A. Labor supply and the market
1. Level and composition of the labor forces
2. Changing patterns of employment
3. Some questions about labor supply and the market

B. Reduction and control of unemployment
1. Types of unemployment
2. Proposed schemes of employment stabilization
3. Continuing problems

C. Labor mobility
1. Types of labor mobility
2. Deterrents to labor mobility
3. Suggested programs to improve labor mobility

V. Wage Determination (units of instruction)

A. Wages, process, and employment
1. Meaning of wages
2. Wages and the productive process
3. The problem of inflation

B. Wages and the national income
1. Concepts of measurement and productivity
2. Determinants of productivity
3. The distribution of national income

C. Wage structures
1. Occupational differences
2. Geographic patterns
3. Industry patterns
4. Wage determination: plant level, individual wages

VI. The Balance Sheet of Labor-management Relations (units of instruction)

A. The control and elimination of poverty in a modern industrial State
1. The extent of poverty
2. The attack on poverty
3. Trends and portents

B. Justice and dignity for all in an industrial democracy
1. The worker—status and goals
2. Management—rights and responsibilities
3. The future of capitalistic society

Texts and References

ADRAIN. *State and Local Governments.*

ARMINE and others. *Manufacturing Organization and Management.*

BACH. *Economics: An Introduction to Analysis and Policy.*

BELL. *Crowd Culture.*

BLOOM and NORTHRUP. *Economics of Labor Relations.*

CLAUDE. *Management in Industry.*

DULLES. *Labor in America.*

FAULKNER. *American Economic History.*

GITLOW. *Labor and Industrial Society.*

GREGORY. *Labor and Law.*

GRIMSHAW and HENNESSEY. *Organizational Behavior—Cases and Readings.*

IRISH and PROTHRO. *The Policies of American Democracy.*

KERR and others. *Industrialization and Industrial Man.*

MCGREGOR. *The Human Side of Enterprise.*

OGG and RAY. *Essentials of American Government.*

PELLING. *American Labor.*

PFIFFNER. *Administrative Organization.*

SAYLES and STRAUSS. *Human Behavior in Organizations.*

SCHEIN. *Organizational Psychology.*

SLITCHTER and others. *The Impact of Collective Bargaining on Management.*

STAGNER and HJALMER. *Psychology of Union-Management Relations.*

LIBRARY FACILITIES AND CONTENT

Dynamic developments causing rapid changes in technological science and practice make it imperative that the student of any technology learns to use a library.

In any evaluation of a technology teaching program, the qualifications of the librarian and the physical facilities, the quality, quantity, pertinency of content, and the organization of the library give a tangible indication of the strength of the program.

Instruction for students in technologies should be library-oriented so that they learn the importance of knowing where they can find information relative to any of the various courses which they are studying. They should learn how to use a library and should form the habit of using it as a tool in the learning process. This knowledge helps to develop a professional attitude in the student and further train him to rely upon libraries to keep abreast of the new developments in a rapidly changing technology.

Instructors of all courses should constantly keep the student aware of the extent to which a library contains useful information which can be helpful as a part of the study in his curriculum.

The growth and success of the graduate technician will depend largely upon his ability to keep abreast of changes in his field. Libraries are information source agencies with trained personnel who classify source data and assist those seeking it to find pertinent information quickly.

Library Staff and Budget

The head librarian usually reports to the top administrative officer of the school and has full faculty status.

American Library Association standards state that "two professional librarians are the minimum number required for effective service in any junior college with an enrollment up to 500 students (full-time equivalent). In addition, there should be at least one nonprofessional staff member. The larger the institution, the more appropriate it will be to employ a higher proportion of nonprofessional staff members. Great care should be taken that professional staff members do not spend their time doing work that is essentially clerical, because this is not only wasteful but also demoralizing."

According to the American Library Association, the library budget should be determined in relation to the total budget for educational and general purposes of the institution; however, the amount to be allocated to the library should be based upon a program of optimum library service in support of the school's goals. The execution of the library program outlined in their standards normally requires a minimum of 5 percent of the total educational and general budget. This minimum percentage is for a well-established library with an adequate collection. It would have to be augmented if there should be a rapid increase in the student body or in course offerings; it would again need to be increased if the library should be made responsible for an audio-visual program. The library budget for a newly organized institution should be considerably higher than 5 percent.

Another criterion for the library budget, approved by the American Library Association, is that the funds for acquiring new library materials should equal or exceed the cost of the total library staff. This is for established libraries, and the expenditure for acquisition of new library materials should be substantially greater when libraries are just starting or when major additions of curriculums are being made.

Library Content

The content of a library must adequately provide the literature devoted to all the subjects in a curriculum and extending somewhat beyond the degree of complexity or depth encountered in classroom activities. Literature dealing with unusually highly specialized aspects of a subject may be acquired as needed or may be borrowed by the librarian from more comprehensive libraries.

The library content should meet the needs both of full-time students and of part-time students pursuing supplemental educational courses designed to upgrade or update their occupational knowledge and skills. In addition, it should serve the day-to-day needs of the instructional staff as they keep current their own technical knowledge by informing themselves about the new developments pertinent to their special field of applied science.

In view of the highly specialized nature of library content for scientific data processing technology, it is recommended that the department head or chief instructor of the technology be a member of a library committee and be responsible for finally approving the reference material selected for the technology and related courses. The librarian, as chairman of such a committee, may be expected to take the initiative in assisting the head of the Scientific Data Processing Technology Department by keeping him informed of new literature and library materials which become available. The librarian should also take the initiative in calling meetings or informally consulting with the head of the department so that, within the limitations of the budget and the overall consideration of total library needs, the technology will acquire its appropriate library content.

The library content may be classified as basic encyclopedic and reference index material, reference books pertinent to the technology, periodicals and journals, and visual aids. Each will be discussed separately.

Encyclopedic and Reference Index Material

This portion of the library content is basic in that it contains the broadly classified and organized cataloging of all available knowledge pertinent to the objectives served by the library and the program which it supports.

Technical Journals, Periodicals, and Trade Magazines

The importance of this portion of the library content has previously been emphasized. These publications represent the most authoritative, most recent, and most nearly complete presentation of new knowledge and new applications of principles to a given specific area of applied science. It is essential that both instructors and students make frequent and systematic use of such literature to keep their technological information up to date.

It is suggested that careful selectivity be exercised in retaining and binding or in microfilming these periodicals for permanent library use. Some represent important reference material which may be used for many years. Some, however, especially the trade journals, should not be bound for permanent reference material, because the really important material which they contain will usually become a part of a handbook or textbook or will be presented in a more compact and usable manner within a year or two.

The following is a typical list of technical journals, periodicals, and trade magazines which would be desirable in the library. This list is given as an example which may suggest appropriate publications to those who are concerned with this type of content for a library supporting scientific data processing technology teaching programs.

Automation: The Penton Publishing Co., Penton Building, Cleveland, Ohio 44113

Automation and Remote Control: Instrument Society of America, 530 William Penn Place, Pittsburgh, Pa. 15219

Communications of the ACM: Association for Computing Machinery, 211 East 43rd Street, New York, N.Y. 10017

Computer Characteristics Quarterly: Adams Associates Inc., 575 Technology Square, Cambridge, Mass. 02139

Computer Digest: American Data Processing, Inc., 4th Floor, Book Building, Detroit, Mich. 48226

Computer and the Humanities (Newsletter): Queens College of the City University of New York, Flushing, N.Y. 11367

Computer Journal: The British Computer Society, Finsbury Court, Finsbury Pavement, London, E.C.2.

Computer News: Technical Information Co., Martins Bank Chambers, P.O. Box 59, St. Helier Jersey, British Channel Islands.

Computers and Automation: Berkeley Enterprises, Inc., 815 Washington Street, Newtonville, Mass. 02160

Computing Report for the Scientist and Engineer: Data Processing Division, International Business Machines Corp., White Plains, N.Y. 10601

Computing Reviews: Association for Computing Machinery, 211 East 43rd Street, New York, N.Y. 10017

Data Processing Digest: Data Processing Digest, Inc., 1140 South Robertson Blvd., Los Angeles, Calif. 90035

Data Processing for Education: American Data Processing Inc., 4th Floor, Book Building, Detroit, Mich. 48226

Data Processing Magazine: Data Processing Magazine, 134 North 13th Street, Philadelphia, Pa. 19107

Datamation: F. D. Thompson Publications, Inc., 205 West Wacker Drive, Chicago, Ill. 60606

D.P.M.A. Quarterly: Data Processing Management Association, 505 Busse Highway, Park Ridge, Ill. 60068

Information Retrieval Letter: American Data Processing, Inc., 4th Floor, Book Building, Detroit, Mich. 48226

Journal of the Association for Computing Machinery: 211 East 43rd Street, New York, N.Y. 10017

Journal of Mathematical Analysis and Applications: Academic Press, Inc., 111 5th Avenue, New York, N.Y. 10003

Journal of Symbolic Logic: Association for Symbolic Logic, Inc., P.O. Box 6248, Providence, R.I. 02904

Operations Research: Operations Research Society of America, Mount Royal and Guilford Avenues, Baltimore, Md. 21202

Operations Research Quarterly: Pergamon Press Ltd., Headington Hill Hall, Oxford, England

Supervisory Management: American Management Association, Inc., 135 West 50th Street, New York, N.Y. 10020

Systems and Procedures: Systems and Procedures Association, 7890 Brookside Drive, Cleveland, Ohio 44138

The Book Collection

The American Library Association states that "a 2-year institution of up to 1,000 students (full-time equivalent) cannot discharge its mission without a carefully selected collection of at least 20,000 volumes, exclusive of duplicates and textbooks. Institutions with broad curriculum offerings will tend to have larger collections; an institution with a multiplicity of programs may need a minimum collection of two or three times the basic figure of 20,000 volumes. The book holdings should be increased as the enrollment grows and the complexity and depth of course offerings expand. Consultation with many junior college librarians indicates that for most, a convenient yardstick would be the following: The bookstock should be enlarged by 5,000 volumes for every 500 students (full-time equivalent) beyond 1,000."

At the initiation of a scientific data processing program, it is recommended that the head of the program and the librarian review the current pertinent reference books available and select a list of books to be placed in the library as regular reference material. A recommended policy is to place in the library only those reference books which are not a part of the regular textbook material for the various data processing courses.

It is suggested that at the beginning of a program such as the one recommended by this curriculum guide, the library should contain at least 200 to 300 reference books on various aspects of data processing technology and its related fields. Beyond the initial 200 to 300 books, from year to year there should be regular and systematic additions to the reference materials in the library supporting the technology, and eventually a weeding out of those references which have become obsolete.

Visual Aids

The same procedure as previously outlined for the acquisition of books pertinent to the data processing technology is suggested for placing visual aids in the library.

In view of current research in methods of teaching the fundamental knowledge and theory of atomic structure and other scientific principles, it is probable that many new visual aid materials may become available in the future.

In addition to the visual aids for teaching physical science and computer principles, there are and probably will continue to be valuable films and other pertinent materials showing research or production which should be used selectively in teaching scientific data processing technology.

LABORATORY FACILITIES, EQUIPMENT, AND COSTS

The laboratory and related classrooms, offices, and storage facilities required for teaching scientific data processing do not present special or unusual conditions peculiar to the technology. Any well-constructed building with suitable utilities may be used. However, if a building is to be constructed to house a data processing technology program, plans should include maximum use of movable partitions to attain the greatest flexibility and utility of space.

General Planning of Facilities

Normal environmental control for data processing technology laboratories and classrooms is necessary; and in geographic areas where extremes of warm weather and high humidity prevail for any appreciable part of the year when the facilities are to be used, air conditioning has been found to be necessary. Any additional consideration related to air conditioning and humidity control is a function of the type and quantity of data processing equipment employed. Resolution of these considerations may best be obtained by the utilization of a close liaison between the facility planners and equipment vendors.

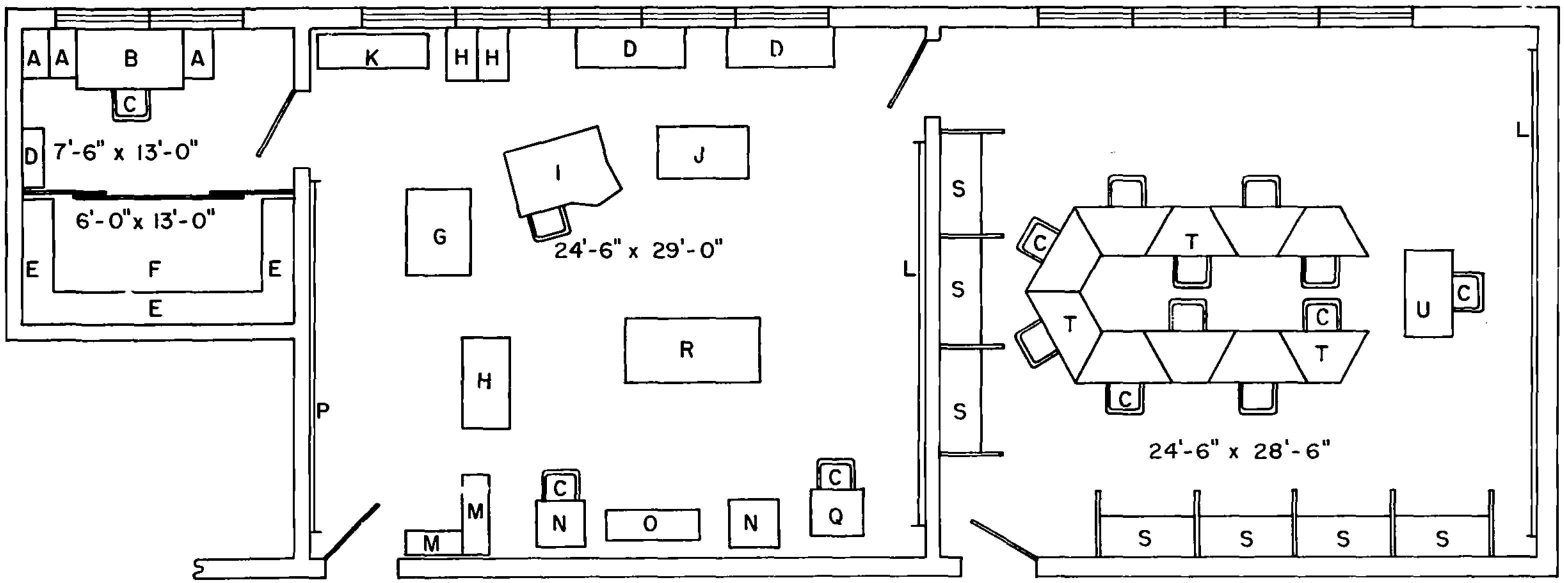
A classroom near the data processing laboratory is desirable. Classrooms and laboratories should be well lighted with a recommended minimum of 50 foot-candles of light at the table or desk tops. Fluorescent lighting is satisfactory.

Determination of required electrical services is a function of equipment selection. The variability of power requirements is such that detailed specifications can be resolved only after equipment determinations have been made. However, it is important that the selected central processing unit be connected to a circuit breaker separate from the general utilities service and other equipment available in the laboratory. It must also be considered that all equipment will be operating simultaneously over extended periods of time.

When planning space requirements for a data processing technology department, many factors must be considered, some of which are: the number of students; available facilities; the number of staff members to be involved; and the length of the program. These factors and many others come into play before suggestions for area allotments can be made. The following discussion has been developed for a 2-year program involving 20 to 25 beginning data processing students, 20 advanced students, and three instructors in the technical specialty courses. Students in excess of this number may be accommodated by use of multiple laboratory sections or by assigning more than two students to each laboratory group.

Laboratory space is the most important area in a data processing department. The laboratories should be planned for optimum convenience and utility for both students and instructors. Figures 10, 11, and 12 represent examples of floor plans of data processing departments. It must be recognized that development of data processing departments is highly dependent upon the types and quantities of equipment available. In many cases, the location of specific equipment will dictate the limitation of variation in locating other equipment. For example, the selection of a location for the central processing unit (CPU) dictates, to a considerable degree, the location of input-output devices, tape units, secondary storage units, and other devices which are physically connected to the CPU. Doorways should be located for easy traffic flow into and out of the laboratory. Storage areas in laboratories should be located so that the instructor can readily control the security of key programs and software. Consideration must also be given to the storage of diagnostic programs and maintenance equipment belonging to equipment vendors. Again, the amount of space required is dependent upon the equipment selected and should be determined during the period of equipment negotiations with the vendor.

Figure 10 shows a layout which includes a program preparation room consisting of individual programming carrels. The advantage of this arrangement is recognized when one considers the degree of concentration required for program writing and the characteristics of individualism and creativity which enter into each meaningful program.



DATA PROCESSING LABORATORY AND OFFICE LAYOUT

A. FILE CABINETS
B. DESK
C. CHAIR
D. BOOKCASE
E. SHELVES
F. GENERAL STORAGE
G. PRINTER
H. CARD FILES
I. CENTRAL PROCESSING UNIT
J. CARD READ AND PUNCH UNIT
K. MASTER STORAGE LOCKER
L. CHALKBOARD
M. STORAGE CABINET
N. CARD PUNCH
O. SORTER
P. BULLETIN BOARD
Q. VERIFIER
R TABLE
S. PROGRAMMING CARRELS
T. STUDENT DESKS
U. INSTRUCTORS' DESK

Figure 10.—Data Processing Laboratory and Office Layout.

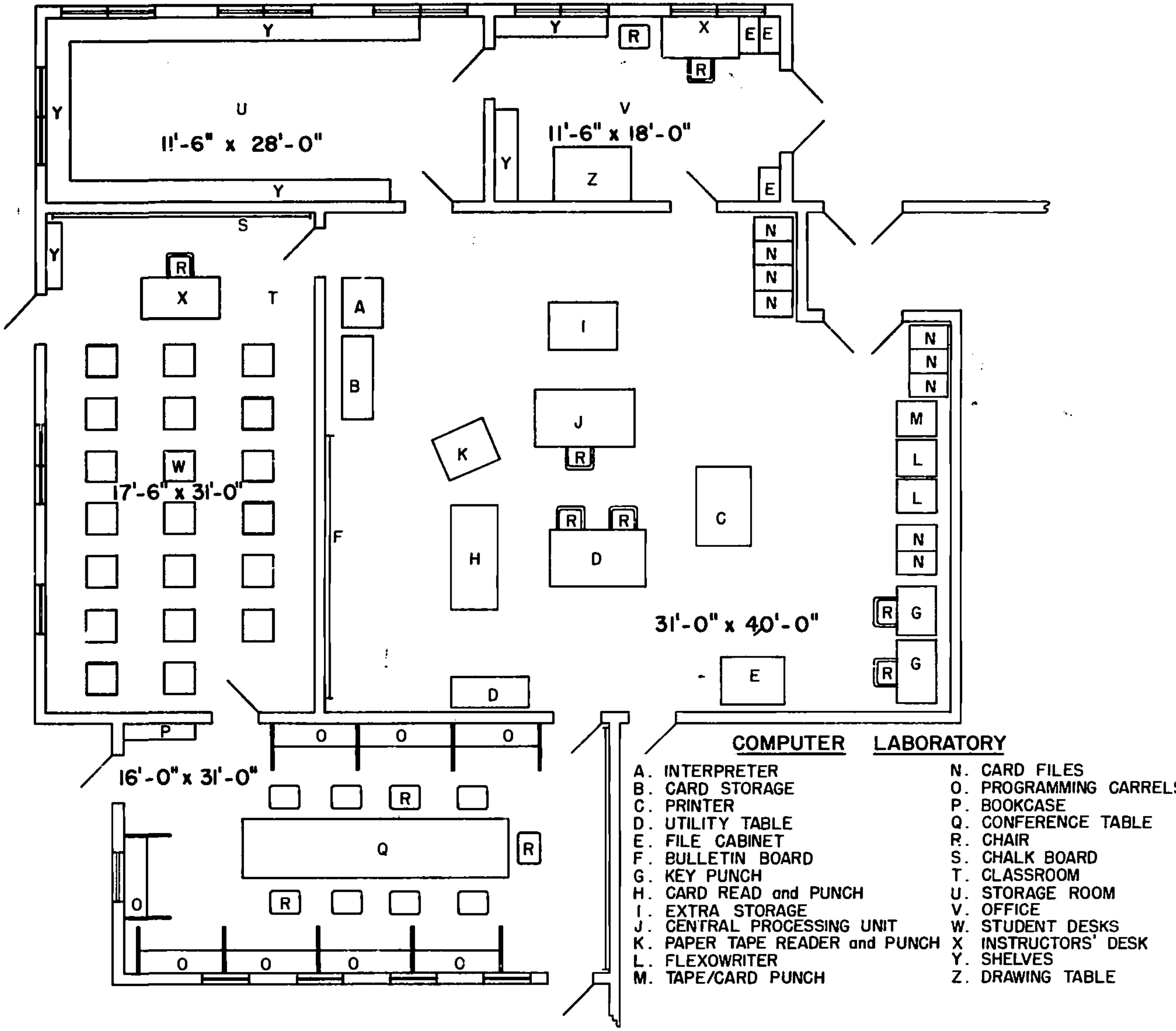
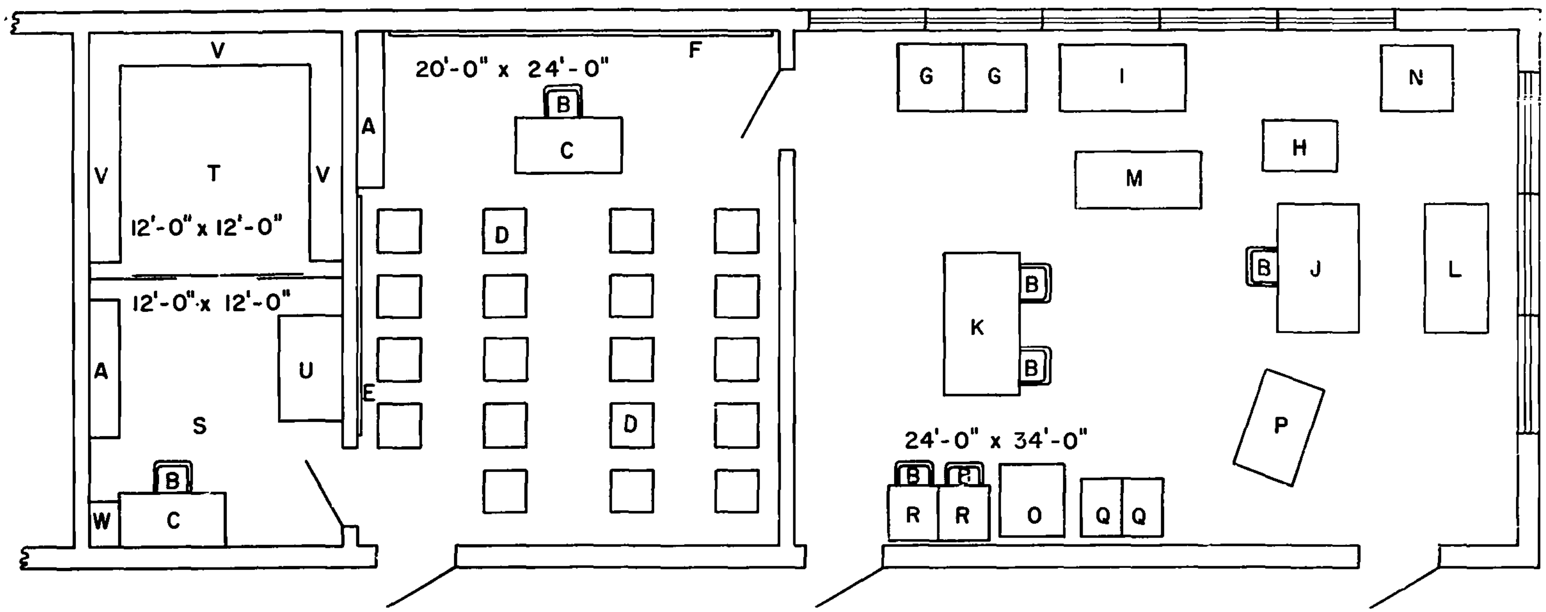


Figure 11.—Computer Laboratory.



CLASSROOM AND COMPUTER LABORATORY LAYOUT

A. BOOKCASE
B. CHAIR
C. INSTRUCTORS' DESK
D. STUDENT CHAIR-DESK
E. BULLETIN BOARD
F. CHALK BOARD
G. MAGNETIC TAPE UNIT
H. PAPER TAPE READER and PAPER TAPE PUNCH
I. MAGNETIC TAPE ADAPTER
J. CENTRAL PROCESSING UNIT
K. PROGRAMMING DESK
L. EXTRA STORAGE UNIT
M. CARD READ and PUNCH
N. TAPE/CARD PUNCH
O. FLEXOWRITER
P. PRINTER
Q. CARD FILE
R. KEY PUNCH
S. INSTRUCTORS' OFFICE
T. STORAGE AREA
U. DRAWING TABLE
V. STORAGE SHELVES
W. FILE CABINET

Figure 12.—Classroom and Computer Laboratory Layout.

Office Space for Staff

Suggested office space for staff is indicated in the examples of schematic diagrams for a data processing department, Figures 10, 11, and 12. Office space should be provided for each instructor, and it is recommended that no more than two staff members be located in any office. More than two staff members occupying an office tends to discourage students from aproaching instructors for assistance.

It is desirable to have a waiting room adjacent to staff offices where students can study comfortably while waiting for the instructor's assistance. The waiting room may house the departmental secretary, who can arrange conference appointments for students if necessary. The conference room shown in Figure 11 may also be used for student and staff conferences. No specialized equipment is needed for data processing department staff offices.

Equipping the Laboratories and Their Costs

The field of data processing requires specific and unique considerations in reference to equipment selection. Rapid innovations in methods and hardware capability necessitate a recognition of rapid obsolescence. Data processing equipment required to conduct an effective training program is varied, expensive, and necessary, and unlike equipment for many of the other technologies, can be purchased or leased and requires a maintenance contract. There are recognized advantages and disadvantages regarding the lease versus purchase decision. Perhaps the most serious disadvantage of purchasing equipment is the resulting tendency to utilize the equipment beyond its useful life. When this occurs, the training program becomes contaminated with obsolescence. The lease arrangement allows for equipment change necessary to maintain currency in techniques and methods.

Administrative units offering scientific data processing technology in several schools will find it advantageous to determine the feasibility of acquiring a single large central processing unit to serve the various schools by means of terminal units. Perhaps the most obvious advantages of this arrangement are reduced equipment costs and the ability to afford the student large-scale computing capability. The primary concern, whether the equipment is of the terminal or stand-alone type, is that such equipment permit the application of programming languages currently in use by industry and business.

Figure 13.—In addition to a computer the equipment must include peripheral or supporting units for a computer system which are up to date with current practice. These high-speed, magnetic tape storage units are examples of such equipment.

Experience has shown that administrative use of data processing equipment in scheduling students, controlling inventory, payroll applications, and numerous other activities is both feasible and beneficial to the entire institution. When administrative tasks are performed on the data processing equipment *it is absolutely necessary* to designate a working schedule that does not interfere with student use. In this regard, consideration must also be given to the danger of overloading the instructor if part of his responsibility is supervision of administrative data processing. The general recommendation is to proceed slowly with administrative tasks which use the same equipment on which students perform their laboratory experiments.

The acquisition and use of surplus equipment to conduct a program of the type presented in this guide are not recommended. Surplus equipment is, in most cases, obsolete and inadequate.

Several computer manufacturers have developed small, relatively inexpensive educational computers which might be complementary to a larger system but should not be acquired as a substitute for equipment within the quoted price range. Admittedly, equipment selection is a difficult portion of the development of a data processing curriculum. It is suggested that full utilization of an industrial advisory committee in regard to equipment selection is *absolutely essential* to the success of the program.

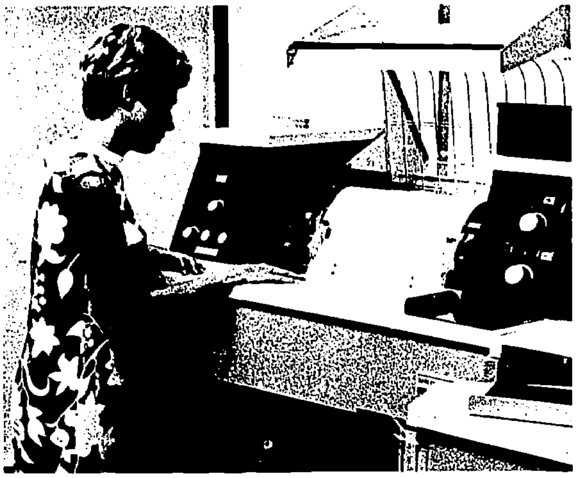


Figure 14.—The printed report is the end product of hours of effort, and for many students becomes the "Moment of Truth" which tests and confirms the validity of their programming efforts. The printer is a necessary part of the equipment in an adequately equipped laboratory for teaching scientific data processing.

The cost of data processing equipment is a prime consideration when planning for a data processing technology. This problem is further complicated by the availability of options associated with each piece of equipment and the consideration of a maintenance contract. In addition, equipment vendors have developed a policy of offering an educational discount ranging from 10 to 60 percent. In view of these many variables, only a general statement based on experience may be made regarding total equipment costs. It is expected that the minimum equipment cost necessary to support a scientific data processing technology program of the type described in this guide ranges from $150,000 to $260,000 without considering any discount. If the decision is to lease rather than purchase, the minimum monthly rent ranges from $3,000 to $5,000 without considering any discount. Whether equipment is purchased or leased, a monthly maintenance fee must be arranged, which varies with specific equipment and options. Determination of maintenance charges must be considered during negotiations with equipment vendors.

Computing Equipment

Item	*Quantity*	*Description*		*Estimated Costs*	*Rental per Month*
1	1	Central processing unit		$ 75,000 to $120,000	$1,400 to $2,000
2	1	Card I/O unit		25,000 to 35,000	500 to 600
3	2	Secondary storage units		35,000 to 45,000	1,000 to 1,500
4	1	Printer		25,000 to 35,000	300 to 450
			Total	160,000 to 235,000	3,200 to 4,550

Auxiliary Equipment

1	3	Key punch machines		3,000 to 4,000	60 to 75
2	1	Sorter		2,500 to 3,000	40 to 50
3	1	Card verifier		2,500 to 3,000	40 to 50
4	1	Flexowriter or remote terminal unit		Not recommended	50 to 200
5	1	Interpreter		5,000 to 6,000	100 to 150
6	4	Card files		200 to 300	
7	1	Sorting rack		50 to 75	
8	3	Card punch desks		100 to 125	
			Total	13,350 to 16,500	290 to 525
			Grand Total	173,350 to 251,500	3,490 to 5,075

Summary of Costs

Cost estimates for the various items are given as a range of cost without consideration of any discount which may be obtained. The costs are stated in this way to provide a relative estimate, and this method of statement of costs is *not to be considered to be a recommendation* that equipment be purchased. *Whether to rent or purchase must be determined specifically for each situation*. The costs assume the acquisition of new equipment of good quality in the quantities indicated, based on prices in 1967.

The foregoing estimates do not provide for the cost of the building, which, if constructed for the program, may be calculated at $13 to $15 per square foot of unfurnished laboratory space. Such space with special utilities and built-in furnishings without portable equipment may be estimated at $25 to $30 per square foot.

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APPENDIXES

Appendix A

Selected List of Scientific or Technical Societies and Associations Concerned with Electronic Computers and Data Processing Applications

A list of some of the professional, scientific, and technical societies concerned with electronic computers and data processing applications may be a useful source of instructional information and reference data.

The selected list which follows is not a complete listing of all such organizations; and inclusion does not imply special approval of an organization, nor does omission imply disapproval of an organization. Details regarding local chapters or sections of societies have been omitted.

It is suggested that teachers and others desiring information from the organizations listed below should address their inquiry to "The Executive Secretary" of the organization. A request for information about the organization and its services, or for specific information usually can be answered promptly by them.

The following societies are listed and briefly described:

American Federation of Information Processing Societies (AFIPS)
Association for Computing Machinery (ACM)
Association for Educational Data Systems (AEDS)
Association of Data Processing Service Organizations (ADAPSO)
British Computer Society
Business Equipment Manufacturers Association (BEMA)
The Computing and Data Processing Society of Canada
Data Processing Management Association (DPMA)
International Computation Center (ICC)
International Federation for Information Processing (IFIP)
Operations Research Society of America (ORSA)
Project on Information Processing (PIP)
Society for Automation in Business Education (SABE)
Systems and Procedures Association

American Federation of Information Processing Societies (AFIPS)
211 East 43rd Street
New York, N.Y. 10017

HISTORY: AFIPS is an outgrowth of the National Joint Computer Committee (NJCC), which was organized in 1951 for the purpose of sponsoring and coordinating the Eastern and Western Joint Computer Conferences. It was recognized that information processing had become a national concern and a need existed for a centralized information source. In recognition of this problem, members of the NJCC caused the AFIPS to be formed on May 10, 1961.

PURPOSE: AFIPS is a society of societies founded to promote the advancement and dissemination of knowledge of the information processing societies. Some of the purposes of AFIPS included in its constitution are: "To promote unity and effectiveness of effort among all those who are devoting themselves to information processing by research, by application of its principles, by teaching or by study; and to foster the relations of the sciences of information processing to other sciences and to the arts and industries."

MEMBERSHIP: Consists of members of associated societies who are engaged in, closely related to, or interested in the information processing sciences.

PUBLICATIONS: The *Proceedings* of each Joint Computer Conference

Association for Computing Machinery (ACM)
211 East 43rd Street
New York, N.Y. 10017

HISTORY: ACM was organized in 1947 as the Eastern Association for Computing Machinery. In 1948, the word Eastern was dropped and it has since been known as the Association for Computing Machinery.

PURPOSE: The Association for Computing Machinery is perhaps the most technically oriented of all the computer and data processing organizations. The purposes of ACM are: (1) "To advance the sciences and arts of information processing including, but not restricted to, the study, design, development, construction, and application of modern machinery, computing techniques and appropriate languages for general information processing, for scientific computation, for the recognition, storage, retrieval, and processing of data of all kinds, and for the automatic control and simulation of processes." (2) "To promote the free interchange of information about the sciences and arts of information processing both among specialists and among the public in the best scientific and professional tradition."

MEMBERSHIP: Any person or institution having interests in accord with the purposes of the association may obtain membership. There are three recognized classes of membership: institutional, regular member, and student member.

PUBLICATIONS:
Journal of the Association for Computing Machinery

Communications of the ACM
Computing Reviews

Association for Educational Data Systems (AEDS)
AEDS Headquarters
State Department of Education
Tallahassee, Fla. 32302

HISTORY: AEDS was formed in 1962 as a professional association for educational data processing and information management personnel.

MEMBERSHIP: AEDS membership consists of directors of school data processing centers, officials of state departments of education, and directors of college and university computer centers.

PUBLICATIONS:
AEDS Bulletin
EDP Newsletter
Journal of Educational Data Processing

Association of Data Processing Service Organizations (ADAPSO)
947 Old York Road
Abington, Pa. 19001

HISTORY: ADAPSO was the result of a meeting in early 1960 between groups of company representatives who came together to consider the feasibility of organizing. Subsequent meetings were conducted and the result was the formation of the ADAPSO on June 8, 1960. The first headquarters office was established in January 1963.

PURPOSE: ADAPSO serves member companies through an inquiry service, legislative activity, simplified accounting, salary surveys, the development of ethical standards, the determination of liability, and the enhancing of a better understanding with the professions, especially accounting, law, engineering, banking, and management consulting.

MEMBERSHIP: Consists of service center organizations concerned with serving clients through data processing for a profit.

PUBLICATIONS:
ADAPSO News
ADAPSO Proceedings
Directory of Data Processing Service Organizations

British Computer Society
Finsbury Court, Finsbury Pavement
London EC2, England

HISTORY: The Society was formed as a result of the independent actions of several groups. The London Computer Group was extremely instrumental in the formulation of groundwork which culminated in the formation of the British Computer Society in 1961.

PURPOSE: Promote advancement and diffusion of knowledge relative to electronic computing and data processing.

MEMBERSHIP: The Society is open to anybody having an interest in the purposes of the organization.

PUBLICATIONS:
The Computer Journal
The Computer Bulletin
Monthly Newsletter

Business Equipment Manufacturers Association (BEMA)
235 East 42nd Street
New York, N.Y. 10017

HISTORY: Organized in 1916 as the Office Equipment Manufacturers Institute and renamed in July 1961. BEMA represents the entire business equipment industry which consists of approximately 50 manufacturers of computers, office machines, furniture, and related supplies.

PURPOSE: To conduct programs designed specifically for the needs and problems of member companies. Among these programs are included market research, establishment of standards, and the operation of the Business Equipment Exposition/Conference.

PUBLICATIONS:
News Bulletin

The Computing and Data Processing Society of Canada
Mr. L. E. S. Green, Secretary
20 Spadina Road
Toronto, Ontario, Canada

HISTORY: Established June 21, 1959.

PURPOSE: The advancement of computing and data processing by sponsoring meetings and conferences; collaborating with educational institutions, research foundations, and manufacturers; publishing and exchanging information; and providing a national source for information.

MEMBERSHIP: All persons actively engaged in the administration, practice, or teaching in business or scientific data processing may hold membership.

Data Processing Management Association (DPMA)
524 Busse Highway
Park Ridge, Ill. 60068

HISTORY: The National Machine Accountants Association was formed in 1951. In the 10-year period following the formation of the National Machine Accountants Association, data processing activities increased at an astounding rate. This rate increase primarily was due to the acceptance of the electronic computer as a vital tool in business and industry. To reflect the changes in the role of data processing, the National Machine Accountants Association was reorganized as the Data Processing Management Association in June 1962.

PURPOSE: DPMA is dedicated to improving the data processing profession by creating better understanding of the characteristics and functions of data processing, especially as they relate to needs for education, dissemination of knowledge, solutions of problems, and the proper relationship of data processing to management.

MEMBERSHIP: DPMA has three classes of membership: regular, associate, and honorary. Persons employed in managerial positions in data processing installations are eligible for regular membership. Associate membership is open to those whose occupational activities are related to direct selling of data processing equipment and supplies.

PUBLICATIONS:
Journal of Data Management

International Computation Center (ICC)
Palazzo degli Uffici, Zona dell E. U. R.
Rome, Italy

HISTORY: Founded in January 1957 as the result of a contract between UNESCO and the Instituto Nazionale di Alta Matematica (Italy). Upon the attainment of a sufficient number of member countries, its permanent position became assured.

PURPOSE: ICC has a threefold objective: (1) provision of consulting services, (2) scientific research, and (3) education.

PUBLICATIONS:
ICC Proceedings
Symposium on Modern Computing Machines
Symposium on Problems of Numerical Analysis
Symposium on the Numerical Solution of Partial Differential Equations with Real Characteristics

International Federation for Information Processing (IFIP)
345 East 47th Street
New York, N.Y. 10017

HISTORY: The decision to form IFIP was the result of a conference sponsored by the United Nations cultural organization which was held in Paris in 1959. The organization was officially formed on January 1, 1960.

PURPOSE: To promote international cooperation for the advancement of the science of information processing and the examination of related mathematical and technical problems.

MEMBERSHIP: Restricted to one organization from each country.

PUBLICATIONS:
IFIP Bulletin
IFIP News
Proceedings of IFIP

Operations Research Society of America (ORSA)
Mt. Royal and Guilford Avenues
Baltimore, Md. 21202

HISTORY: Founded under the leadership of Professor Philip M. Morse at Arden House, Harriman, N.Y., in 1952.

PURPOSE: Advancement of operations research exchange of information, the establishment through and maintenance of professional standards of competence for work known as operations research, improvement of methods and techniques of operations research, and the encouragement and development of students of operations research.

MEMBERSHIP: Persons meeting certain professional requirements may be elected members; others may become associate members.

PUBLICATIONS:
Operations Research, The Journal of the Operations Research Society of America
Operations Research Bulletin
International Abstracts in Operations Research

Project on Information Processing (PIP)
National Science Teachers Assoc ation
Box 201, Montclair State College
Upper Montclair, N.J. 07043

HISTORY: In 1961, the International Business Machines Corporation contacted the National Science Teachers Association in an attempt to devise a solution to the problem of relating modern data processing techniques to the classroom. As a result of this contact a committee of representatives from interested groups was formed and in 1961 PIP was designated as a project on information processing with headquarters at Montclair State College. PIP is no longer affiliated with the National Science Teachers Association, but is a part of Montclair State College.

PURPOSE: To serve as a clearing house for information on computer education in the secondary schools.

PUBLICATIONS:
Careers in Electronic Data Processing
Computers—Theory and Uses
PIP Newsletter

Society for Automation in Business Education (SABE)
Dr. E. Dana Gibson, President
Professor of Office Management
San Diego State College
San Diego, Calif. 92115

HISTORY: Formed in May 1961.

PURPOSE: To advance the cause of business education by accelerating an interest in and involvement with automation, computers, data processing, programmed learning, and related areas.

PUBLICATIONS:
SABE Data Processor

Systems and Procedures Association
7890 Brookside Drive
Cleveland, Ohio 44131

HISTORY: In May 1944, a group of businessmen organized themselves in Philadelphia for study, research, and training. Several years later, the Philadelphia group merged with a similar group in Delaware. The result of this and subsequent mergers was the formation of the Systems and Procedures Association.

PURPOSE: To gain information and exchange ideas relative to systems and procedures. The Association collects and disseminates information on systems courses taught throughout the nation.

MEMBERSHIP: Open to those who are actively engaged in systems and procedures.

PUBLICATIONS:
Systems and Procedures Journal
International Newsletter
Ideas on Management

Appendix B

Suggested Procedure for Laboratory Report Writing

GENERAL CHARACTERISTICS

Documentation of programs indicating procedures, flow charts, and program coding is an essential part of the programmer's occupational activities. In most cases, these reports are submitted to individuals who have not been actively engaged in the program writing: hence, the reports must be clear and concise enough to leave no doubt concerning the method of procedure and the interpretation of the results. Data should be summarized and shown whenever it simplifies its comprehension or interpretation.

The report should be written in the past tense and in the third person. It should be impersonal throughout. The report must be complete in itself so that it can be followed by a reader without extensive knowledge of the program under consideration. A good report is thorough, orderly, neat, and grammatically correct.

SPECIFICATIONS

1. Write with ink or use a typewriter.
2. Use 8½- by 11-inch paper (ruled paper for handwriting).
3. Write on one side of the paper only.
4. Draw all illustrations, flow charts, and curves neatly and carefully.
5. Letter or type all information on drawings, flow charts, and curves. Do not mix lettering styles.
6. Assemble the sheets in the order given in the following report outline. Submit the material in a standard report folder with the brads inserted through the back cover only, with the heads on the outside.

REPORT OUTLINE

The material should be arranged in the following order:

I. Title Page
II. Introduction
III. Method of Investigation
  A. Problem definition
  B. Systems flow chart
  C. Program flow chart
  D. Coded program
IV. Results
  A. Data
    1. Source of data
    2. Observed and calculated data
  B. Program output
  C. Running time
V. Analysis of Results
VI. Questions
  (Not more than one of the above six divisions should be included on a single page. Omit Roman numerals.)

DISCUSSION OF REPORT OUTLINE

I. Title Page
On this page should appear the name of the school, the course number and title, the date performed, the date submitted, the name of the student reporting, and the name of coworker or coworkers. This page may be omitted if the form printed on the report folder includes these items.

II. Introduction
The introduction should be a concise statement setting forth the aim and scope of the investigation.

III. Method of Investigation
Procedure. In this section, a general description of the procedure should be given. It should be comprehensive but brief. The enumeration and detailed description of routine mechanical operations and their sequence—such as closing switches, handling cards, turning knobs, and so forth—should in general be avoided. However, when a specific method of mechanical operation is necessary to assure the validity or accuracy of results, it is important that the essential details be included in the description.
Diagrams. Each diagram should have a figure number, and should be referred to in the text material by that number. Each figure should have a descriptive title. Small diagrams may be included in the body of the description, or several may be drawn on one separate sheet if the result is not crowded. Standard symbols should be used.

IV. Results
Data. The original observed data and the calculated data should be presented in tabular form. If the observed data require corrections, these should be made before tabulation.
Sample Calculations. This section should consist of a sample of a complete calculation of each type involved in the determination of calculated data and the solution of problems. When a succession of calculations is required in order to reach a final result, the same set of observed data should be used in carrying through the successive sample calculations, i.e., the same sample figures that are selected from a data column should be used in all calculations involving that set of data.
Curves. All curve sheets should conform to the following specifications:
1. Use "20 to the inch" coordinate paper, 8½ by 11 inches, for rectangular plots.
2. Plot the first quadrant where only one quadrant is needed.
3. In general, make the axes intersect within the sectioned part of the paper. Leave the curve sheet margins blank.

4. Plot the independent variable as abscissa and the dependent variable as ordinate.
5. In general, start the scale of the dependent variable, but not necessarily the scale of the independent variable, at zero.
6. Choose scales that are easy to use and that do not allow points to be plotted to a greater accuracy than that justified by the accuracy of the data.
7. Indicate points plotted from data by visible dots or small circles.
8. Draw a smooth average curve through the plotted points except in cases in which discontinuities are known to exist. Use a French curve in drawing the curves.
9. Place a title containing all pertinent information on each curve sheet. The title should be lettered or typed. Label the axes and show the units in which they are marked.
10. Draw only related curves on the same sheet.
11. Insert curve sheets in the report so that they can be read from the bottom or right side.
12. Use ink for everything on the sheet except the curves themselves; these should be drawn with a colored pencil.

V. Analysis of Results

The analysis of results is the most important section of the report. As the name implies, it should be a complete discussion of the results obtained. Part of the discussion should deal with the accuracy or reliability of the results. It is suggested, where applicable, that this section consist of a careful treatment of the effect on the results of the following:

1. Errors resulting from the necessity of neglecting certain factors because of physical limitations in the performance of the program
2. Errors in roundoff
3. Errors in coding
4. Errors in packaged programs

An important part of the discussion should be a comparison of the results obtained with those which would reasonably have been expected from a consideration of the theory involved in the problem. Whenever the theory is apparently contradicted, the probable reasons should be discussed. When results are given in graphical forms as curves, the shape of each curve should be carefully explained. Such an explanation should state the causes for the particular shape the curve may have. Any original conclusions drawn as a consequence of the laboratory procedure and a study of the results obtained should be included in this section.

VI. Questions.

In this section should be included answers to any questions which are given as a part of the laboratory execise.

Appendix C

Sample Instructional Materials

The items included in this section are intended to serve as guides in the development of instructional material. The formal classwork is usually organized around textual material to facilitate the coordination of outside study. The laboratory work, by contrast, is almost entirely custom designed. This is necessary for at least two very practical reasons:

1. Little commercially published material exists for this type of instruction.
2. Laboratory work must be organized to make maximum use of available materials and facilities.

It should be emphasized that material of this nature requires careful preparation. It must be prepared by persons with industrial experience in order to assure its validity.

TYPICAL MATERIAL FOR A UNIT OF INSTRUCTION

One of the primary advantages of the full-time day program is in the coordination of classroom or theory study with laboratory activities. In order to illustrate this coordination, a representative unit of instruction was selected from the course entitled Statistical Programming and the Life Sciences. It includes:

Instructional Guide
Specific Reading Assignments
Laboratory Unit Related to Instruction
Suggested Standard for Laboratory Report

INSTRUCTIONAL GUIDE

Statistical Programming and the Life Sciences
Topic: Division II-2 correlation
Lecture Time: Three 50-minute periods
Laboratory Time: Three 3-hour periods
Outside Study: Twelve hours (minimum)

LECTURE 1: Definition and application of correlation theory.

Reference: Borko. *Computer Applications in the Behavioral Sciences*, Chapters I and X.

1. Areas for correlation application
2. Mathematical description of correlation
3. Graphical illustrations
4. Formulae for correlation
5. Work a correlation problem for demonstration
6. Design flow chart for correlation program
7. Summarize
8. Make assignment

Assignment For Next Lecture Period

Reading Assignment: Freund and Williams. *Modern Business Statistics*, pp. 307-314.

Problem Assignment: Problem 8, p. 313. Solve problem 8 and design a flow chart suitable for computer application.

LECTURE 2: Programming for solution of correlation problem

1. Review flow chart used for lecture 1 demonstration.
2. Design input format.
3. Design output format.
4. Write program in FORTRAN explaining the purpose(s) for each instruction.
5. Summarize.

Assignment For Next Lecture Period

Reading Assignment: Freund and Williams, pp. 314-320.

Problem Assignment: Code problem 8, p. 313 from the flow chart designed for lecture 2.

LECTURE 3: Program execution and evalution

1. Review correlation program created in lecture 2.
2. Demonstrate program execution on computer.
3. Analyze output and verify.
4. Summarize.

Assignment For Next Lecture Period

Reading Assignment: Freund and Williams, pp. 320-326.

Problem Assignment: Design flow chart and code problem 1, p. 325 for computer solution.

LABORATORY UNIT

1. Design a flow chart, code a program, execute, and present an informal report of the process, procedure and analysis, for the correlation between two variables (X, Y) each consisting of 10 observations.
2. Description: the correlation coefficient is used to measure the strength of the relationship which exists between two variables. The definition formula is:

$$c = \frac{\mathrm{cov}_{xy}}{\sqrt{\sigma^2_x} \cdot \sqrt{\sigma^2_y}}$$

which equals

$$\frac{\dfrac{\Sigma (x-\bar{x})(y-\bar{y})}{N-1}}{\sqrt{\dfrac{\Sigma (x-\bar{x})^2}{N-1}} \cdot \sqrt{\dfrac{\Sigma (y-\bar{y})^2}{N-1}}}$$

the range of c is from +1.0 to -1.0.

Formulas used:

1. Mean:

$$\bar{x} = \frac{\sum_{i=1}^{n} X_i}{N}$$

2. Standard Deviation:

$$\sigma = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{N}}{N-1}}$$

3. Covariance:

$$cov_{xy} = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{N}}{N-1}$$

4. Correlation:

$$\frac{\frac{\sum XY - \frac{(\sum X \sum Y)}{N}}{N-1}}{\sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{N}}{N-1}} \cdot \sqrt{\frac{\sum Y^2 - \frac{(\sum Y)^2}{N}}{N-1}}}$$

Program Objective:
Compute means, standard deviations, and covariance for X and Y, also the correlation between X and Y.

Input Data:
Card No. 1 CC 1 = 6 Identification CC7 = 10 Number of Observations
Data Cards CC 11 = 20 X Variable CC 31 = 40 Y Variable
Last Card Blank

Program Listing

```
C     SAMPLE PROGRAM CALCULATING MEAN,
      STANDARD DEVIATION AND CORRELA-
      TION
    1 FORMAT (A4, A2, I4)
C     READ IDENTIFICATION COL 1-6 NUMBER
      OF OBSERVATIONS COL 7-10
    2 READ (1, 1) ID1, ID2, N
C     IF CARD BLANK, STOP JOB
      IF (N) 8,8,4
    3 FORMAT (2H1, A4,A2,5X, 7HNO OBS=,I4)
    4 WRITE (3,3) ID1,ID2,N
C     INITIALIZE COUNTERS
      SXY=O.
      SX=O.
      SY=O.
      SSX=O.
      SSY=O.
C     READ X, COL 11-20, Y, COL 31-40, AND DE-
      VELOP SUMS FOR N OBSERVATIONS
      DO 6 I=1,N
    5 FORMAT (10X,F10.5,10X,F10.5)
      READ 1,5) X, Y
      SXY=SXY+X*Y
      SSX=SSX+X**2
      SSY=SSY+Y**2
      SX=SX+X
      SY=SY+Y
    6 CONTINUE
      AN=N
C     COMPUTE COV X,Y VAR X AND Y, MEAN
      X AND Y, CORRELATION
      COVXY= (SXY-SX*SY/AN)/(AN-1.)
      VARX= (SSX- SX**2/AN)/(AN-1.)
      VARY= (SSY-SY**2/AN)/(AN-1.)
      STDX=SQRT(VARX)
      STDY=SQRT(VARY)
      CORR=COVXY/(STDX*STDY)
      XBAR=SX/AN
      YBAR=SY/AN
      WRITE (3,7) XBAR, STDX, YBAR, STDY,
      COVXY, CORR
    7 FORMAT (5X, 'MX=',F8.3,1X, 'STD X =',F8.3,
      1X, 'MY=',F8.3,1X,'STD Y-',
      1F8.3,1X,'COVXY=',F10.5,1X, 'CORRELATION
      =',F6.4)
      GO TO 2
    8 STOP
      END
```

Input Data:

CORREL 10 (identification)

X	Y
6.1	7.2
3.9	4.6
1.1	2.3
5.6	4.1
7.3	9.7
3.2	4.8
.5	1.3
4.7	6.21
8.3	11.4
2.2	3.6

Output:

```
CORREL        NO OBS = 10
    MX - 4.290  STDX = 2.594  MY = 5.491
    STDY = 3.182  COVXY = 7.70814  Corre-
    lation = 0.9341
```

Much of the effectiveness of formal training rests upon the standards required in reporting. Employers stress the importance of communications especially for the liaison-type jobs so often assigned to the technician. Perhaps the most thorough approach to this in the instructional program is found in the formal and informal reporting of laboratory projects, and also in design problems, research studies, and field study of industrial installations.

The form and style of the formal report should be established early in the program in order to attain a degree of uniformity. "The Suggested Standards for Laboratory Reporting" included here and in appendix B are intended for the student's orientation and follow accepted patterns of reporting. *A common deficiency in student work is inattention to detail.* The guide used should direct attention to the importance of detail as well as logical conclusions in the reporting process.

The marking of the report itself constitutes an important part of the instruction. Unless this is done carefully and as objectively as possible the student may be misled and actually misinformed.

In general, a laboratory project is selected to illustrate principles rather than applications. In many cases, the applications provide efficient means of illustration; nevertheless, the principle should be emphasized. Illustrative of this is the course Statistical Programming and the Life Sciences. The emphasis throughout this course is on programming techniques not life science theory. Excellent programs can be built around problems arising in the life sciences, projects that illustrate the adaptation of programming to specific needs.

It should also be recognized that most of the value of laboratory work lies in the substantiation of theoretical concepts. For this reason, mathematical analysis and proof should be required in laboratory work whereever possible. By a judicious use of the formal and informal reports, it is possible to elicit individual thought from each student. In addition, this reporting technique provides a means for improving the student's communication skills.

LABORATORY REPORT

The laboratory report should represent a complete documentation of the program. This would include: (1) problem definition, (2) flow chart, (3) FORTRAN program, (4) sample input data, and (5) sample output. A section of the report should be concerned with hardware procedures and offer an indication of running time.

This type of report should be developed for each program of any significance and is considered an informal report. The formal report is outlined in appendix B.

AN EXAMPLE OF A "USER GROUP" PROGRAM

Often programs may be obtained from the user group organization. Frequently these programs may be used with little or no modification required. The following presents a typical program obtained from the 1620 user group and is representative of the type of programs available.

Users Group Library

Program Abstract

Title: Analysis of Variance, Means, and SDs for Subgroups with Unequal or Equal N.

Author: John Doe, School of Education, City College, City of Takia

Address: 123rd Street & Convent Avenue, Ellerbe, N.C. Phone: 833-0707, Extension 201 or 511

Purpose: Research in the social sciences often involves an unanticipated loss of subjects giving rise to an experimental sample with an unequal number of cases, or observations, in the component groups. The present program is specifically designed for such contingencies, and will compute a one-way analysis of variance, means, variances, and standard deviations even though each of the subgroups has a different number of subjects. The program may also be used for problems where an equal number of cases is found in each group. Output is available with several options, and in the typical case gives fully labeled analysis of variance table, and means, variances, standard deviations, and Ns for each subgroup.

Method: Standard statistical method is used.

Analysis of Variance, Means, and SDs for Subgroups with Unequal or Equal N

Disclaimer: The usual disclaimer of responsibility is made.

Purpose. Research in the social sciences often involves an unanticipated loss of subjects giving rise to an experimental sample with an unequal number of cases, or observations, in the component groups. The present program is specifically designed for such contingencies, and will compute a one-way analysis of variance, means, variances, and standard deviations even though each of the subgroups has a different number of subjects. The program may also be used for problems where an equal number of cases is found in each group. Output is available with several options, and in the typical case gives fully labeled analysis of variance table, and means, variances, standard deviations, and Ns for each subgroup.

Method: Standard statistical method is used.

Compilation: The AFIT[1] compiler was used in the compilation of this program. AFIT has the advantage of providing for virtually format-free input data in either fixed, or floating-point mode, though running time is longer than by the use of standard FORTRAN.

Input: Each of the subgroups may have as many as 1,000 cases. The program may easily be modified for use with larger N by changing the dimension statement at the beginning of the program (DIMENSION X (1,000)) to the desired number of cases. The data for each group should be punched consecutively on one or a series of cards with at least one blank space after each piece of data. Specific instructions follow:

Card Preparation:

1. On the first card punch the number of subgroups in fixed point, at least one blank space, the number of cases, or observations in that group, followed by at least one blank space.
2. The data for the first group is then punched consecutively on one or a series of cards with at least one blank space after each piece of data. Columns 1-72 may be used. The following hypothetical example of data:
   3 4 1.8 1.9 2.1 2.4

[1] AFIT. An Improved Fortran. IBM Users Library, No. 1.1.010

would be interpreted to mean that there are *three* subgroups, the first of which has *four* pieces of data, and the data was 1.8, 1.9, etc.

3. A new card should be used for each subgroup.
4. The first number on each card should give the number of cases in that subgroup; the preparation of the rest of the data is as indicated above.

Output: The kind of output obtained depends on switch settings. In each case the data are identified by appropriate labeling provided for by a variety of format statements.

All Sense Switches Off: Output gives: (1) the identification number of the subgroup, i.e., the order in which the subgroups were entered; (2) the mean; (3) variance; (4) standard deviation; (5) number of cases in the subgroup; and (6) the analysis of variance table with fully labeled entries for source of variance, degrees of freedom, mean square, and F ratio.

Sense Switch 1 On: Gives only the data described in numbers 1-5 above.

Sense Switch 2 On: In addition to the data described above, sum of X, sum of X squared and N for each of the subgroups is punched out, whether sense switch 1 is on or off. The sums are punched immediately after each mean. In order to simplify reading of this data it is suggested that all of the cards giving this data be assembled together prior to printing.

The number appearing on the line before labels for the means and analysis of variance data denotes the number of times the program has run. Since the program is compiled for continuous operation, this number identified the sequence to which the following data belongs.

```
C     ONE-WAY ANALYSIS OF VARIANCE,XBAR,
      SD, N MAY BE EQUAL OR UNEQUAL
C     DATA MUST BE PUNCHED BY ROW, NOT
      COLUMN
      DIMENSION X(1,000)
    1 INDEX=0
    2 INDEX=INDEX+1
    3 SXA=0.
      SXSQA=0.
      HOLD=0.
      SFN=0.
      M=0
   10 SX=0.
      SXSQ=0.
      M=M+1
      IF(M-1)16,16,20
   16 READ 100,K
   20 READ, 100,N
      FN=N
      DO 30 J=1,N
      READ 100,X(J)
      SX=SX+X(J)
   30 SXSQ=SXSQ+X(J)*X(J)
      XBAR=SX/FN
      VAR=(FN*SXSQ-SX*SX)/(FN*(FN-1.))
      SD=SQRT(VAR)
      IF (M-1) 35,35,36
   35 PUNCH 110,INDEX
   36 PUNCH 111,M,XBAR,VAR,SD,N
C     ALL SENSE SWITCHES OFF GIVES MEAN,
      VAR,SD,N, AND ANAL OF VARIANCE
C     SENSE SWITCH 2 ON GIVES SUM X, SUM X
      SQUARE, AND N
      IF (SENSE SWITCH 2) 205,37
C     SENSE SWITCH 1 ON GIVES ONLY MEAN,
      VARIANCE,SD, AND N
   37 IF (SENSE SWITCH 1) 38,40
   38 IF(M-K)10,300,300
  205 IF(M-1)206,206,210
  206 PUNCH 112,INDEX
  210 PUNCH 113,M,SX,SXSQ,N
      GO TO 37
   40 SXA=SXA+SX
      SXSQA=SXSQA+SXSQ
      HOLD=HOLD+(SX*SX/FN)
      SFN=SFN+FN
   50 IF(M-K)10,60,60
   60 COR=SXA*SXA/SFN
      TSSQ=SXSQA-COR
      BSSQ=HOLD-COR
      WSSQ=TSSQ-BSSQ
      A=K
      DF1=A-1.
      DF2=SFN-A
      DF3=SFN-1.
      BMSQ=BSSQ/DF1
      WMSQ=WSSQ/DF2
      F=BMSQ/WMSQ
      PUNCH 105,INDEX
      PUNCH 106,BSSQ,DF1,BMSQ
      PUNCH 107,WSSQ,DF2,WMSQ
      PUNCH 108, ISSQ,DF3
      PUNCH 109,F
      IF(SENSE SWITCH 9)300,2
  100 FORMAT(I72)
  105 FORMAT(I2,2X,6HSOURCE4X,14HSUM OF
      SQUARES9X,2HDF9X,11HMEAN SQUARE)
  106 FORMAT(7HBETWEEN,3X,F16.5,3X,F8.1,9X,
      F16.5)
  107 FORMAT(6HWITHIN,4X,F16.5,3X,F8.1,9X,
      F16.5)
  108 FORMAT(5HTOTAL,5X,F16.5,3X,F8.1)
  109 FORMAT(2HF=,F12.6)
  110 FORMAT(I2,8X,4HMEAN,12X,3HVAR,11X,
      2HSD,9X,1HN)
  111 FORMAT(I3,F16.5,2F12.6,7X,I5)
  112 FORMAT(I2,6X,8HSUM OF X,5X,11HSUM OF
      X SQ,10X,1HN)
  113 FORMAT(13,F16.1,2X,F16.1,4X,I5)
  300 PAUSE
      GO TO 2
      END
```

INPUT DATA [2]

4 21 6 4 3 7 13 9 4 10 8 9 8 5 5 10 9 15 10 6 4 5 7
19 5 3 4 3 3 4 0 3 4 4 3 3 4 2 5 3 3 1 2
13 4 7 3 7 4 8 7 4 8 4 11 13 9
10 8 5 6 7 7 9 7 10 4 3 3

SAMPLE OUTPUT UNDER VARIOUS CONDITIONS

ALL SENSE SWITCHES OFF

1	MEAN	VAR	SD	N	001
1	7.47619	9.661904	3.108360	21	002
2	3.10526	1.543859	1.242521	19	003
3	6.84615	9.141025	3.023412	13	004
4	6.27272	5.418181	2.327698	11	005

1 SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	006
BETWEEN	213.53560	3.0	71.17853	007
WITHIN	384.90190	60.0	6.41503	008
TOTAL	598.43750	63.0		009

F = 11.095585

SENSE SWITCH 1 ON

2	MEAN	VAR	SD	N	011
1	7.47619	9.661904	3.108360	21	012
2	3.10526	1.543859	1.242521	19	013
3	6.84615	9.141025	3.023412	13	014
4	6.27272	5.418181	2.327698	11	015

SENSE SWITCH 1 AND 2 ON

3	MEAN	VAR	SD	N	016
1	7.47619	9.661904	3.108360	21	017
2	3.10526	1.543859	1.242521	19	020
3	6.84615	9.141025	3.023412	13	022
4	6.27272	5.418181	2.327698	11	024

3	SUM OF X	SUM OF X SQ	N	018
1	157.0	1367.0	21	019
2	59.0	211.0	19	021
3	89.0	719.0	13	023
4	69.0	487.0	11	025

[2] Sample problem taken from: Edwards. *Experimental Design in Psychological Research*, pp. 133-134. Answers to this problem appear on page 387 of the same book.

Appendix D

Audiovisual Aids

The following aids are examples of those available in 1967 which may be of assistance in teaching the following courses:

A. Introduction to Data Processing
B. Electric Accounting Machines
C. Data Processing Mathematics
D. Computer Programming
E. Business System Designs and Development

FILM STRIPS AND SOUND TAPES

	Course
American Management Association, 1515 Broadway, New York, N.Y. 10036:	
Data and Decision: four parts, color, sound	A,D, E
Operations Research: three parts, color, sound	E
Booz, Allen & Hamilton, 135 South LaSalle Street, Chicago, Ill. 60603:	
Business and Electronics: slidefilm, with script, 1 hr.	A, D
Burroughs Corp., 6071 2nd Avenue, Detroit, Mich. 48202 (or nearest branch office):	
The Beauty of It (savings and loan applications): 35mm., color, sound, 30 min.	A, B, E
COBOL (produced by Westinghouse): 35 mm., color, sound, 20 min.	A, D
Control Input for ADP: 35 mm., color, sound, 27 min.	A, B, E
Cure for Dataphobia (mechanization for doctors and clinics): 35 mm., color, sound, 18 min.	A, B, E
Data for Diagnosis (hospital accounting): 35 mm., color, sound, 22 min.	A, B, E
Design for Throughput (B200): 35 mm., color, sound, 17 min.	A, E
On the Road to Decision (auto dealer accounting): 35 mm., color, sound, 20 min.	A, B, E
The Open Road (auto dealer accounting): 35 mm., color, sound, 20 min.	A, B, E
Serving Through Better Systems (CPA accounting systems): 35 mm., color, sound, 17 min.	A, B, E
They Pay Their Way (banking applications): 35 mm., color, sound, 20 min.	A, B, E
This Business of Education (school accounting): 35 mm., color, sound, 18 min.	A, B, E
To Bridge the Gap (control and conversion): 35 mm., color, sound, 18 min.	A, B, E
Your Investment in Inventory (inventory accounting): 35 mm., color, sound, 20 min.	A, B, E
Cresap, McCormick & Paget, 342 Madison Avenue, New York, N.Y. 10017	
An Introduction to Electronic Data Processing: slidefilm, 1½ hr.	A, D
Ernst & Ernst, 120 Broadway, New York, N.Y. 10005	
Electronic Computing Equipment: slidefilm, 2 to 3 hr.	A, C
IBM Corp., Film & TV News Activities, 590 Madison Avenue, New York, N.Y. 10022	
1001 Data Transmission System: 35 mm., color, sound tape	A, E
1401 Data Processing System: 35 mm., color, sound tape	A, D
1418 Optical Character Reader: 35 mm., color	A, D
1620 Data Processing System: 35 mm., color, sound	A, D
Consolidated Functions in Ordinary Life Insurance: 35 mm., color, sound	A, D
Data Processing for Banks: 35 mm., color, sound	A, E
Data Processing for Savings and Loan Associations: 35 mm., color, sound	A, E
Data Processing for the Wholesale Drug Industry: 35 mm., color, sound	A, E
Distribution Accounting: 35 mm., color, sound	A, C, E
The Educated Computer: 35 mm., color, sound	D, E
Education in Action: 35 mm., color, sound	A, E
Fire and Casualty Agency Accounting: 35 mm., color, sound	A, D
Further Steps in Mechanization: 35 mm., color, sound	A, E
Hospital Accounting: 35 mm., color, sound	A, D
IBM 1410 Data Processing Systems: 35 mm., color, sound	A, D
IBM 7074 Data Processing Systems: 35 mm., color, sound	A, D
IBM Datacenters: 35 mm., color, sound	E
Installation of Unit Record Equipment: 35 mm., color, sound	A, B
Job Shop Simulation	A, D
The Magic Window — Principles of Punched Card Accounting: 35 mm., color, sound	A, B
Management Science: 35 mm., color, sound	D, E
Manufacturing Control: 35 mm., color, sound	A, E
New Power for Numerical Control: 35 mm., color, sound	A, D

Principles of Electronic Data Processing: 35 mm., color, sound .... A, D
Public Utility Engineering: 35 mm., color, sound .... A, C
Rent or Buy: 35 mm., color, sound .... A, E
Retail Accounts Receivable: 35 mm., color, sound .... A, E
Sales Forecasting: 35 mm., color, sound .. A, E
Service to Local Government: 35 mm., color, sound .... A, E
Service to Schools: 35 mm., color, sound .. A, E
Time for Management of Men, Material, Money .... A, D
Time to Grow—Installation of Systems Equipment: 35 mm., color, sound .... A, E

Remington Rand Corp., Audiovisual Aids Department, 315 Park Avenue, South, New York, N.Y. 10010

The 1004, VA U 3551: 35 mm., sound, color, 12 min., 1962 .... A, B, E

Operations Research, AMA VA U 2830, 3 parts, 35 mm., color, sound, 52 min. ... E
In basic business language this set of filmstrips examines the aims, analytical tools, results, and limitations of this management technique.

Part I. *Operations Research—What It is:* 17 min.
Traces the development of OR from its inception during World War II to its present uses in business and industry, to provide management with a better, more objective basis for making decisions.

Part II. *Operations Research—How It Works:* 22 min.
Shows in a step-by-step illustration how OR is applied to two specific problems representative of the broad range of problems OR can handle.

Part III. *Scope and Limitations:* 13 min.
Demonstrates how the OR team defines the problem, selects the appropriate measure of effectiveness, and collects the essential data required for the more complex problems.

Public Utilities Accounting, VA U 2256: 35 mm., color, sound, 14 min., 1960 .... A, B, E
Using the Public Utility *1924 Report on Customer Accounting Practices and Policies* as a basis, briefly surveys the evolution of data processing in utilities from 1946 to 1958; cites the problems realized and how in 1958 Univac Card-Punching Printer revolutionized utility customer billing operations; highlights the many applications and processing advantages offered to utilities by combining the Card-Punching Printer with the UNIVAC Solid-State Computer. Stresses solid-state flexibility and capability.

This Business of Numbers, VA U 1201 Rev. I: 35 mm., color, sound, 20 min., 1960 .... A, C
From the cave man to the modern scientist, arithmetic is traced with amusing cartoons from its beginnings to modern data processing systems.

UNA and the Univac, VA U 2013: 35 mm., color, sound, 16 min., 1960 ...... A, B, C

MOTION PICTURE FILMS

Burroughs Corp., 6071 2nd Avenue, Detroit, Mich. 48202 (or nearest branch office)

Electronic Bank Bookkeeping on the Job: 16 mm., color, sound, 12 min. .... A, B, E
F-2000 Computer: 16 mm., color, sound, 18 min. .... A, E
The First Alert (ALRI): 16 mm., color, sound, 15 min. .... A
Highway to Infinity (ATLAS Guidance Computer): 16 mm., color, sound, 18 min. .... General
Mark of Computence: 16 mm., color, sound, 20 min. .... General
More than Miraculous (MICR Input): 16 mm., color, sound, 23 min. .... A, E
Pilot for Atlas (ATLAS Ground Guidance Computer): 16mm., color, sound, 5 min. .... A
The Power to Serve: 16 mm., color, sound, 27 min. .... General
Program for Progress: 16 mm., color, sound, 27 min. .... A

Eastman Kodak Co., Department 8-TR, 343 State Street, Rochester, N.Y. 14608

You're on the Team: 16 mm., color, sound, 20 min.

General Precision, 1680 Wisconsin Avenue N.W., Washington, D.C.; or Commercial Computer Division, 101 West Alameda Avenue, Burbank, Calif.; or Commercial Computer Division, 6511 Oakton Street, Morton Grove, Ill. 60053

P.I.N.T.: 16 mm., black and white, sound, 50 min. (instructional film on programming.) D
R.P.C. 4000: 16 mm., color, sound, 20 min. (description of the "4000" computer.) A, D

IBM Corp., Film and TV News Activities, 590 Madison Avenue, New York, N.Y. 10022

Automatic Computers: 16 mm., black and white, 30 min. .... A, D
The Bank: 16 mm., sound, color, 19 min. ... A, D
The Cards that Count: 16 mm., sound, color, 15 min. .... A, B
City at Night—Mathematics Exhibit: 16 mm., sound, black and white, 45 min. . C
Costs that Make Sense: 16 mm., sound, color, 15 min. .... A, D

The Disks that Are Cylinders: 16 mm., sound, color, 11 min. A, D

The IBM 1404 Printer: 16 mm., sound, color, 8 min. A, D

The IBM 1438 Alphametric Optical Reader: 16 mm., sound, color, 11 min. A, D

IBM Research Presents a Progress Report on Language Translation Equipment: 16 mm., sound, black and white, 4 min. E

Information Retrieval: 16 mm., sound, color, 18 min. E

Insurance Information Bulletin No. 1: 16 mm., sound, color, 12 min. A, D

Introduction to Feedback: 16 mm., sound, color, 12 min. E

Man Into Space: 16 mm. or 35 mm., color, 8 min. D

Mathematical Peep Shows: 16 mm., sound, color, 13 min. C

A Moon Is Born: 16 mm., sound, color, 4 min. E

The Next Step: 16 mm., sound, color, 15 min. A, D

No Margin for Error: 16 mm., sound, black and white, 5 min. A, E

The Question Tree: 16 mm., sound, color, 13 min. E

The Report Generator: 16 mm., sound, color, 9 min. D

Merit Production Inc. of Calif., 441 South Beverly Drive, Beverly Hills, Calif. 90212

Breakthrough: 16 mm., color, 35 min. D, E

McGraw-Hill Book Co., Text-Film Department, 330 West 42nd Street, New York, N.Y. 10036

See It Now—Automation: 16 mm., black and white, 90 min. A, D

National Office Management Association, Willow Grove, Pa. 19090

Integrated Data Processing: 16 mm., sound A, E

Radio Corp. of America, EDP Division, Government Marketing Office, 1725 K Street, NW., Washington, D.C. 20006

Demonstration of RCA 501 EDP System: 16 mm., color, sound, 15 min. A, D

Space Age Administration: 16 mm., color, sound, 20 min. A, D

Remington Rand Univac, Audiovisual Aids Department, 315 Park Avenue South, New York, N.Y. 10010

Census '60, VA U 2012: 16 mm., black and white, sound, 13 min., 1960 A, E
An explanation of why and how U.S. Census data is collected, compiled, and evaluated using FOSDIC (Film Optical Sensing Device for Input to Computers) and the UNIVAC 1105 Scientific Computer.

Computers Come to Marketing (Fortune Magazine film) VA U 2821: 16 mm., sound, black and white, 33 min., 1960 E
A dramatization of the many factors encountered by an evaluation committee involved in a computer study.

Decisions, Decisions, Decisions, VA U 2345: 16 mm., sound, black and white, 12 min., 1960 A, E
A description of similations, or "games," using the UNIVAC I at Franklin Institute, Philadelphia, Pa. The film, made during an actual "play," summarizes the objectives, goals, and results, tangible as well as formulative, realized by the participants.

The Eastern Air Lines 490 Real-time System: 16 mm., black and white, sound, 4 min., 1962 A, E
Brief presentation of Eastern Air Lines 490 Real-time Reservation System in operation at the Charlotte, N.C., central site.

Months into Minutes, VA U 1442: 16 mm., sound, color, 10 min., 1958 A, E
An introduction to the units and operation of the UNIVAC 1103 Scientific Computer, highlighting oil, utility, and National Defense applications.

No Time for Cookie Jars, VA U 1402: 16 mm., sound, color, 20 min., 1957 A, E
Prefaced with a brief cartoon history of toll road accounting, this film presents up-to-date machines and methods for collection of tolls for both carrier and interchange toll systems. Featured machines are the Synchro-Matic, the Alphabetical Tabulator, UNIVAC 120, and UNIVAC File Computer.

Numerical Control—Solid-state, VA U 3177: 16 mm., sound, color, 10 min., 1961 A, E
A demonstration of automatically controlled machine tools used in the manufacture of metal parts for the aircraft industry. Shows how the UNIVAC Solid-State Computer prepares control media for machine tools making it possible to fabricate highly complex parts faster and more economically than could be done with conventional tooling methods.

Sights and Sounds of Progress, VA U 3181: 16 mm., sound, color, 23 min., 1961 A, D, E
A summary of advancements during 1961 in engineering, research, facilities, and new products of the Sperry Rand Corp.

Then and Now, VA U 3236: 16 mm., color, sound, 12 min., 1961 A, E
An account of the development of ENIAC, the first electronic computer, by

J. Prosper Eckert and John W. Mauchly, co-inventors of the system. Following their account of ENIAC, they discuss their current interests and activities.

Truck Route to Better Records, VA U 1670: 16 mm., black and white, sound, 17 min., 1960 .... A, B, E
The "Z Line" realizes its records do not offer adequate information for sound management decisions. The investigation of other trucking firm methods and procedures reveals punched card installations ranging from the basic to those using the UNIVAC 60 and Solid-state Computers.

Advantages in areas such as payroll, interline data, maintenance, sales commissions, billing accounts receivable, and ICC reports are pointed out. Simplicity, speed, and accuracy are stressed as vital points in an effective accounting system.

What Do You Want? VA U 1736: 16 mm., sound, color, 20 min., 1960 .... A, E
Traces the development of electronic computers from ENIAC to UNIVAC III. Emphasizes how UNIVAC, backed by the resources of Sperry Rand, pioneered and will continue to be a leader in the development and production of computing systems. J. P. Eckert, co-inventor of the first digital computer, gives a glimpse at the computers of the future, exploring such areas as speed, storage, and application.

OVERHEAD PROJECTOR FOILS

IBM Corp. Films and TV News Activities, 590 Madison Avenue, New York, N.Y. 10022

- Tape-controlled Carriages, #922, 923—4 foils .... B
- 77 Collator—7 foils .... B
- 305 Ramac—21 foils C
- 402–403 Accounting Machine—15 foils .... B
- 407 Accounting Machine—10 foils .... B
- 519 Document-originating Machine—5 foils B
- 528 Accumulating Reproducer—9 foils .... B
- 602 A Calculating Punch—7 foils .... B
- 604 Electronic Calculating Punch—7 foils .... B
- Organizational Concept of Business—5 foils .... A
- Data Preparation and Classification—39 foils .... A, B
- Calculating Machines, #602A, 604—24 foils .... B
- Accounting Machines, #402–3, 407—29 foils .... B
- Other Machines, #46–47, 63, 65–66, 101, 528, 824, 884—55 foils .... B
- Special Devices—18 foils .... B
- Mounts for Overhead-projector Foils (empty mounts for use in mounting foils) .... General, B
- Container for Visuals (box to store foils, filmstrip cans, and slide containers) .... General, B
- #77 Control Panel Chalkboard .... B
- #85–87 Panel Chalkboard .... B
- #402–403 Control Panel Chalkboard .... B
- #407 Control Panel Chalkboard .... B
- #514 Control Panel Chalkboard .... B
- #519 Control Panel Chalkboard .... B
- #533 Control Panel Chalkboard .... D
- #521–541 Control Panel Chalkboard .... B
- #529–542 Control Panel Chalkboard .... B
- #552 Control Panel Chalkboard .... B
- #557 Control Panel Chalkboard .... B
- #650 Planning Chart Chalkboard .... D
- #650 Console Chart Chalkboard .... D
- #5081 Control Card Chalkboard .... A, B
- #602A Planning Chart Chalkboard .... B
- #604 Planning Chart Chalkboard .... B
- #101 Control Panel Chalkboard .... B
- #85–87 Card Feed Schematic Chalkboard .... B
- #514–519 Card Feed Schematic Chalkboard .... B
- #528 Control Panel Chalkboard .... B
- #528 Planning Chart Chalkboard .... B
- #705 Programming Chart Chalkboard .... D
- #705 Auto Coder Programming Chart Chalkboard .... D
- #602A Control Panel Chalkboard .... B
- #604 Control Panel Chalkboard .... B
- #650 Soap Programming Chart Chalkboard .... D
- #407 Control Panel Chalkboard .... B
- #305 Control Panel Chalkboard .... D
- #380 Control Panel Chalkboard .... D
- #370 Control Panel Chalkboard .... D
- #323 Control Panel Chalkboard .... D
- #305 Programming Chart Chalkboard .... D
- #610 Control Panel Chalkboard .... D
- #610 Programming Chart Chalkboard .... D

Note: The Data Processing Management Association, 524 Busse Highway, Park Ridge, Ill., publishes a *Catalog of Audiovisual Aids for Data Processing Systems and Automation.* This publication may be obtained from the Association.

DEMONSTRATION EQUIPMENT

Philco Corp., Techrep Division, C and Ontario Streets, Philadelphia, Pa. 19100

- Binary Numbers Trainer #368–37032 .... A, C
- Computer Systems Lecture Demonstration, Unit #463–4667 .... A, D, E
- Display Rack #368–33335 for #463–4667 Demonstration Unit .... General
- Power Supply #368–33335 for #463–4667 Demonstration Unit .... General

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